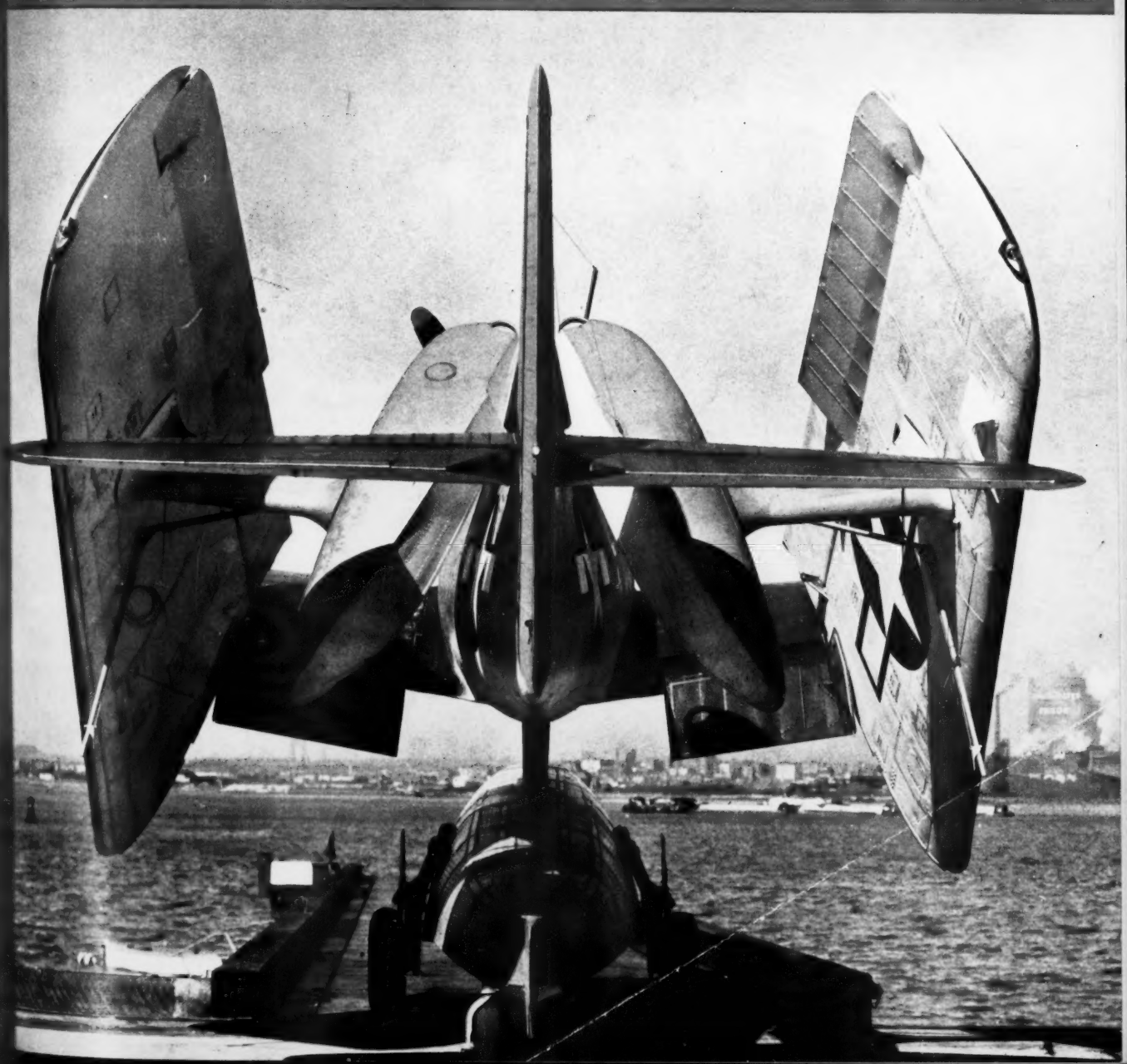
AERONAUTICAL ENGINEERING REVIEW

OCTOBER 1946



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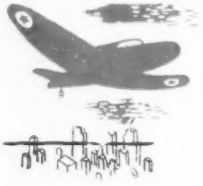

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Cover—The Edo XOSE-1 Scout observation seaplane. (See page 41.)

AERONAUTICAL ENGINEERING REVIEW

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American Airlines DC-4's

The 3000 psi hydraulic system of the DC-4's operated by American Airlines has the Vickers Units shown below.

The Vickers Piston Type Pump has a maximum recommended operating pressure of 3000 psi and maximum recommended speed of 3750 rpm at which its output is 13.3 horsepower. As the pump weighs only 6.8 lb it has the exceptionally low weight ratio of 0.51 lb per hp. The volumetric efficiency of 94% and the overall efficiency of 88% are exceptionally high for 3000 psi units.

The 7½" Vickers 3000 psi Accumulators assure maximum safety because of their forged construction. Other important features are large capacity and light weight.

The Vickers Motorpump serves as an additional hydraulic power source for operation of the hydraulic system in emergencies. The pilot is then able to give undivided attention to flight maneuvers under emergency conditions.

Vickers Bulletin 45-41 gives additional information about the most complete line of 3000 psi hydraulic equipment for aircraft.

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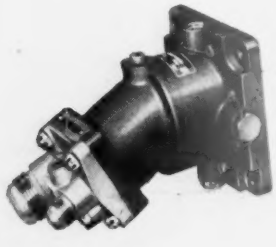
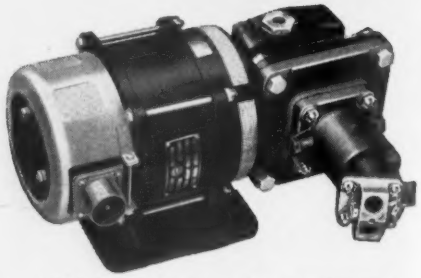
Vickers 3000 psi Accumulator



Vickers 3000 psi Constant Displacement Piston Type Pump



Vickers Motorpump for maximum operating pressure of 3000 psi

I.A.S. News

A Record of People and Events of Interest to Institute Members

I.A.S. to Have Booth at Cleveland Aircraft Show

Institute Exhibit Located in Area Devoted to Air Age Theme. Cleveland Section Plans to Act as Host to Visiting Members and Guests.

MEMBERS who expect to attend the National Aircraft Shows in Cleveland next month will welcome the news that a display booth and lounge, sponsored by the Institute, will be at their service for the duration of the Shows. This will provide a convenient meeting and resting place for members and their guests, as well as for visitors interested in learning more about the Institute's activities and functions.

The Cleveland Section, under the able chairmanship of Robert J. Minshall, has volunteered to assist with the preliminary details, provide a staff for the booth, and steer the Institute's activities throughout the show. At least one member of the Section will be on hand at all times to give information and assistance to visitors. Captain S. Paul Johnston, Director of the Institute, and Bennett H. Horchler, Executive Vice-President, will represent the New York Office in Cleveland during this period.

While final details are yet to be arranged, it is expected that the booth will house certain exhibits from the Aeronautical Archives and museum in New York, in addition to those displays that portray the fundamental services and activities of the organization.

Members and friends visiting Cleveland on November 15–24 are invited to use the Institute's booth to the best advantage.

Robert J. Minshall, Chairman of the Cleveland Section.

The I.A.S. booth will be found in the Specialized and Informational Exhibits Area, directly facing the Theme Center (*right*).

Air Commodore Whittle Receives Daniel Guggenheim Medal for 1946

The Daniel Guggenheim Medal Board of Award has selected Air Commodore Frank Whittle, R.A.F., to receive the Daniel Guggenheim Medal for 1946 "for pioneering the development of turbo-jet propulsion of aircraft."

Air Commodore Whittle, who is Technical Adviser on Engine Design and Production to the Controller of Supplies at the Ministry of Supply (Air), evolved the idea of jet-propelled aircraft while a cadet at the Royal Air Force College at Cranwell, England, in 1928. After several years' assignment to flying duties, he resumed research on this idea at the Flying Training School at Digby. He then entered Cambridge University to take a course in mechanical science, which he completed with first class honors in 1936. In the same year, he and two other ex-R.A.F. officers organized the firm of Power Jets, Ltd. The following year the Whittle engine made its first test run, and the Air Ministry put Whittle on the Special Duty List to work full time on the engine. The British Government placed an order for its first jet-driven aircraft in 1939, and in 1941 the Gloster Whittle experimental airplane made a successful flight.

Shortly after that, the British Government turned over its information on jet propulsion to the American Government, and Whittle made a secret visit to the United States to advise on the testing and design of the American models. In 1944, the British Ministry of Supply took over Power Jets, Ltd., and Air Commodore Whittle handed over all his shares and rights as a gift to the nation.

The Daniel Guggenheim Medal was created for the purpose of honoring persons who make notable achievements in the advancement of aeronautics. Provision for the Medal was made in 1928 by a gift from the Daniel Guggenheim Fund for the Promotion of Aeronautics. The Board of Award is composed of the American recipients of the Medal; a representative of the Fund's custodian, United Engineering Trustees, Inc.; and three men appointed by each of three scientific societies—the American Society of Mechanical Engineers, the Society of Automotive Engineers, and the Institute of the Aeronautical Sciences.

Dr. Hunsaker Elected Director of Goodyear Tire & Rubber Company

Dr. J. C. Hunsaker, Chairman of the National Advisory Committee for Aeronautics and an Honorary Fellow and Past-President of the Institute, has been elected a Director of The Goodyear Tire & Rubber Company. Dr. Hunsaker holds directorships in the Sperry Corporation, the Shell Union Oil Corporation, and the McGraw-Hill Publishing Company. He is also Head of the Departments of Mechanical and Aeronautical Engineering at the Massachusetts Institute of Technology.

J. C. Hunsaker.

Barnaby Receives Air Medal

Captain Ralph S. Barnaby, U.S.N., Commanding Officer of the Naval Aircraft Modification Unit, Johnsville, Pa., and a Fellow of the Institute, has been awarded the Air Medal "for meritorious achievement in aerial flight as a pilot of gliders and towed aircraft." Captain Barnaby holds the No. 1 soaring pilot license of the United States, and in 1929 he made the longest soaring flight made by an American up to that time. In 1930 he made the first glider descent from a dirigible. His decorations include the Legion of Merit, the Victory Medal, the Defense Medal, the American Theater Medal and the World War II Victory Medal.

The citation accompanying the Air Medal reads: "For meritorious achievement in aerial flight as a Pilot of Naval Aircraft from 1942 to 1944. Zealous and far-sighted in his efforts to advance naval aviation and explore the possibilities of a practical glider and towed-aircraft program, Captain Barnaby not only conceived and planned many innovations in this pioneering field, but also personally conducted numerous flight tests of experimental and hazardous nature to prove the feasibility of the techniques he advocated. His professional skill, resourceful ingenuity and devotion to duty reflect great credit upon Captain Barnaby and the United States Naval Service."

I.A.S. Calendar

December 17, 1946	Tenth Wright Brothers Lecture, Washington, D.C.
January 28–30, 1947	Fifteenth Annual Meeting, New York, N.Y.
March, 1947	Aircraft Propulsion Meeting, Cleveland, Ohio

For further details see page 13.

Stress Analysis Society Meets

The annual meeting of the Society for Experimental Stress Analysis will be held at the Hotel New Yorker, New York City, December 9–11, 1946. The meeting will include a symposium on "Telemetering of Aircraft Flight Observations."

Executive Changes at Pan American

John C. Leslie, Vice-President of Pan American World Airways System formerly in charge of the Atlantic Division, and an Associate Fellow of the Institute, has been transferred to the system's executive office. He will represent the company in the Air Transport Association and the International Air Traffic Association and will serve as liaison in connection with intergovernmental air-transport agreements. James H. Smith, Jr., an Industrial Member of the Institute, has been elected Vice-President in charge of the Atlantic Division, succeeding Mr. Leslie. Thomas Wolfe, an Associate Fellow of the Institute, has been elected Vice-President in charge of the Pacific-Alaska Division.

Gifts to the Aeronautical Archives

William A. M. Burden gave 453 bound volumes of periodicals published in 17 foreign countries. Of these, 241 volumes were from France and 173 volumes from Germany. The gift also included bound periodicals from Argentina, Australia, Canada, Czechoslovakia, Finland, India, Italy, the Netherlands, Poland, Portugal, Rumania, Russia, Spain, Switzerland, and Yugoslavia. Mr. Burden included 300 aeronautical posters, more than 350 air-route maps, photographs, more than 100 display cards, a piece of the *Graf Zeppelin*, and

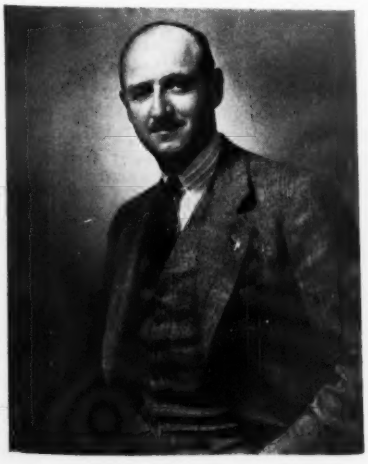
George W. Brady.

other aeronautica from his extensive collection. Added to his generous gifts of previous years, these bound periodicals and posters comprise one of the great contributions to the Institute collections by an individual.

Insignia and buttons of Imperial Airways, British Overseas Airways, Empire Airways, and the Norwegian and Swedish Air Forces were received from S. F. Dodes. Three aeronautical buttons were received from John H. Andrews, and five buttons from the Russell Uniform Company through the courtesy of Howard A. Zeinner.

Photographs and booklets of German aircraft, and an aeronautical card game of her invention, were given by Miss Lilly E. Hoffmann. Major G. Herndon Robinson gave a color drawing of the Wright airplane of 1903. A set of 15 colored aeronautical prints was received from the British Embassy through the courtesy of Peter Masefield. A pin of the Aero Club of Greece was received from Prof. D. Hondros of the University of Athens.

Otto E. Kirchner.



Additional gifts were received from American Petroleum Institute, *Aviation* magazine, Food Research Institute, Dr. Alexander Klemin, Southwest Airways Company, Transcontinental & Western Air, Inc., U.S. Bureau of Mines, Civilian Production Administration, Library of Congress, Naval Air Transport Service, Navy Department, Securities and Exchange Commission, Senate Committee on Military Affairs, Surplus Property Administration, War Assets Administration, and the House and Senate Document Rooms.

New Corporate Members

Irving Air Chute Company, Inc., manufacturers of "Irvin" parachutes, has recently become a Corporate Member of the Institute. The head office and factory of the company are located at Buffalo, N.Y., with branches in Great Britain, Canada, Sweden, and Rumania.

During the war the Irving company's entire facilities were devoted to supplying parachutes to the Allied nations. Turning its efforts toward building commercial sales, the company is now producing the chair parachute for installation in the seats of passenger aircraft and privately owned cabin airplanes.

Piper Aircraft Corporation has also recently become a Corporate Member of the Institute. The business of the company is primarily the manufacture and complete assembly of light airplanes, of which it has been a leading producer for the past 8 years. In that period its total output has amounted to more than 15,022 airplanes. During the war the corporation turned out more than 5,500 light airplanes for the armed forces, most of which were a modification of the Cub Special model, designated by the Army as the L-4. Current models are of two types: the standard two-place Cub Special equipped with a 65-hp. Continental engine, and the three-place Cub Super Cruiser powered by a 100-hp. Lycoming engine.

Sections and Branches

New York Section

The following officers were elected for the 1946–1947 term: Chairman, George W. Brady, Chief Engineer, Propeller Division, Curtiss-Wright Corporation; Vice-Chairman, William R. Enyart, President, Simmonds Aerocessories, Inc.; Secretary-Treasurer, Otto E. Kirchner, Director of Aircraft Engineering, American Airlines, Inc.; Section Representative to the Nominating Committee for Area Councilors, Jerome Lederer, Chief Engineer, Aero

William R. Enyart.

Insurance Underwriters. Advisory Committee: Peter De Florez, Development Engineer, American Overseas Airlines, Inc.; Lewis E. Knerr, Jr., Staff Engineer, Pan American World Airways System; Franklin T. Kurt, Project Manager, Grumman Aircraft Engineering Corporation; Jerome Lederer; E. M. Lester, Director of Engineering, Ranger Aircraft Engines Division, Fairchild Engine and Airplane Corporation; and Frederick K. Teichmann, Professor and Chairman of the Department of Aeronautical Engineering, New York University.

Academy of Aeronautics

At a meeting held on August 1 the following officers were elected: Chairman, Horace B. Edwardsen; Vice-Chairman, John L. Feltham; Treasurer, Albert H. Demchak; Secretary, Richard J. Edwardson; and Sergeant-at-Arms, Joseph Di Mauro.

Jerome Lederer.

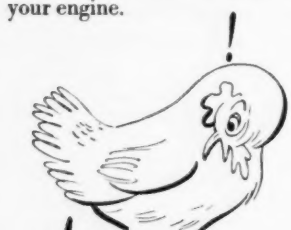
HANGAR FLYING

LOCKHEED

The Unhatchable Egg

Research engineers out at Lockheed have been crowing about their new egg that flies but won't hatch. It's a *Constellation* engine assembly called the Universal Power Egg, and the way it simplifies maintenance is something.

For instance: gone are the antics that crews used to go through trying to expose an engine on a transport. Hinged, detachable cowl panels on the Egg flip back like the hood on a car, and there's your engine.



What's more, the oil tank in the Egg is forward of the fire wall. This may not sound exactly sensational, but one of the big time-eaters during engine changes has always been the inaccessibility of the tanks for cleaning.

The Power Egg is so universal that, theoretically, you could install Wrights on one side of the *Constellation* and P&W's on the other. No airline has tried this.

The previous Egg was all right; but Lockheed characteristically developed a better one. And it's this kind of self-starting ingenuity that makes good pilot-room talk and better ships.

L to L for L

©1946, Lockheed Aircraft Corp., Burbank, Calif.

News of Members

Milton B. Ames, Jr., has become Head of the Aerodynamics Group at the Washington, D.C., office of the National Advisory Committee for Aeronautics.

Robert R. Anderson has returned from active duty with the U.S. Navy to rejoin Douglas Aircraft Company, Inc., as a Stress Analyst.

David A. Anderton is now an Aerodynamicist in the General Engineering and Consulting Laboratory of General Electric Company. He was previously associated with Grumman Aircraft Engineering Corporation.

Ammon S. Andes, formerly of Consolidated Vultee Aircraft Corporation, has joined the faculty of the University of Kansas in the Aeronautical Engineering Department.

Charles T. Aubrey is now an Aerodynamicist at North American Aviation, Inc. He previously held a similar position at Chance Vought Aircraft Division of United Aircraft Corporation.

E. R. Barber has returned from active duty with the U.S. Navy and has joined Boeing Aircraft Company as a Sales Research Analyst.

Martin E. Barzelay is now a Design Engineer at Republic Aviation Corporation. He had been with the Civil Aeronautics Administration.

George P. Bentley, formerly of Sperry Gyroscope Company, Inc., has become President of Instrument Development Laboratories, Inc.

Clay C. Boswell, Jr., has joined North American Aviation, Inc., as a Stress Analyst. He leaves the University of Minnesota, where he has been a Research Assistant.

John E. Burkam has left the U.S. Navy and has entered the University of Cincinnati as a Graduate Student.

George D. Carter has joined Boeing Aircraft Company as a Project Stress Engineer. He was formerly a Structures Engineer at Lockheed Aircraft Corporation.

Jack M. Cherne has been discharged from the U.S. Army Air Forces and has become a Stress Analyst at Republic Aviation Corporation.

Ernest B. Code, former Engineering Test Pilot for Boeing Aircraft Company, has joined West Coast Airlines as Operations Manager.

Lyle M. Crist has entered Indiana University to do graduate work in Technical Journalism.

Craig C. Davis has joined Ministerio Da Aeronautica (Brazil) as an Instructor. He had been an Instructor at the J. P. Riddle Company.

Robert N. Dobbins is now Special Supervisor at the Essex County Vocational School, having recently been discharged from the U.S. Navy.

Edward E. Foster, formerly Head of the Technical Engineering Department at Columbia Aircraft Corporation, has joined the Pilotless Plane Division of Fairchild Engine and Airplane Corporation as Chief Structures Engineer.

Carl L. Frederick has joined Fredric Flader, Inc., as Vice-President in Charge of the Engineering Physics Division. He was formerly Chief of the Physics Department at Cornell Aeronautical Laboratory.

James L. Glascock has returned from active duty with the U.S. Navy to rejoin the Curtiss-Wright Corporation as an Engineer.

Malcolm H. Gotterer has been discharged from the U.S. Army Air Forces and has joined the Federal Telephone & Radio Corporation as a Designer.

Victor F. Hack is now a Plastics Engineer at North American Aviation, Inc. He has returned from active duty with the U.S. Army Air Forces.

William R. Hardin has left the U.S. Navy and has enrolled as a Student at the University of Minnesota.

William R. Hawthorne has joined the faculty of the Massachusetts Institute of Technology as Associate Professor in the Department of Mechanical Engineering. He had been Deputy Director of Scientific Research (Engines) at the Ministry of Aircraft Production (England).

Russell Hays has formed his own company, Diversified Enterprises, Inc.

Earl R. Herring, formerly President of Kinner Motors, Inc., and Airplane Manufacturing and Supply Corporation, has been elected President of Pacific Airmotive Corporation.

Harold M. Hipsh, Jr., has entered the California Institute of Technology as a Student. His previous association had been with the Allison Division of General Motors Corporation.

Henry Hochfield has rejoined Associated Foundries and Manufacturers, Inc., as Chief Engineer.

Willard A. Hoffman, formerly Vice-President of Command Aircraft Corporation, is now a Flight Test Project Engineer with the U.S. Navy.

John W. Hoover has been appointed to the faculty of the University of Alabama as Associate Professor and Coordinator of Flight Training in the Aeronautical Engineering Department.

Roger F. Horton has been appointed Engineering Sales Manager at Farmingdale Aircraftsmen Manufacturing Corporation.

Arthur S. Irwin, formerly a Senior Development Engineer at Bell Aircraft Corporation, has been elected Vice-President and Chief Engineer of Warren Ricketts and Sons, Inc.

Robert W. Jenny has joined the Pilotless Plane Division of Fairchild Engine and Airplane Corporation as a Senior Layout Draftsman. He had been a Design Engineer at Curtiss-Wright Corporation.

Walter H. Johnson has become a Program Engineer at the Supersonic Wind Tunnels Laboratory, Aberdeen Proving Grounds.

Erle Martin.

M. Z. Krzywoblocki has been appointed to the faculty of the University of Illinois as Associate Professor of Aeronautical Engineering.

Stanley S. La Sha, formerly of Bell Aircraft Corporation, has become a Designer at North American Aviation, Inc.

Oscar Leiding has resigned the Associate Editorship of *Air Transport* magazine to do free-lance work.

Erle Martin has been appointed Acting General Manager of the Hamilton Standard Propellers Division of United Aircraft Corporation, in addition to his present post as Engineering Manager.

Andrew I. McKee, Jr., has become a Structural Design Engineer at Douglas Aircraft Company, Inc. He was formerly with Pan American World Airways System.

Leopold R. Michel, formerly with the Polaroid Corporation, has joined Douglas Aircraft Company, Inc.

George B. Miller, Jr., has returned from active duty with the U.S. Navy and has become an Aerodynamicist at Consolidated Vultee Aircraft Corporation.

Murray L. Miller has joined the staff of the Educational Services Division, Air University. Formerly he had been associated with Taylorcraft Aviation Corporation.

Marvin H. Mutch is now an Engineering Draftsman at the Wichita Division of Boeing Airplane Company, having recently returned from duty with the U.S. Navy.

Norton B. Moore, formerly Manager of Research at Aerojet Engineering Corporation, has been appointed Director of Engineering, Aircraft Research and Development Division, Willys-Overland Motors, Inc.

William A. Oconnicof has become a Stress Analyst at Ryan Aeronautical Company. Previously he had been with Consolidated Vultee Aircraft Corporation.

Alexander Pappas is a Stress Analyst at Sikorsky Aircraft Division of United Aircraft Corporation, having returned from duty with the U.S. Army Air Forces.

Norman A. Parker has been appointed Head of the Department of Mechanical Engineering at the University of Illinois. He had held a similar post at the University of Colorado.

Lawrence M. Patrick, formerly an Instructor at Wayne University, has become Director of Wayne Engineering Research Institute.

Claude P. Pound, Jr., has returned from the U.S. Navy to rejoin Taylorcraft Aviation Corporation as a Stress Analyst.

George C. Prill, formerly with Transcontinental & Western Air, Inc., is now Manager of the Office for Civil Aeronautics Administration Liaison, Pan American-Grace Airways, Inc. (Lima, Peru).

Samuel T. Robinson has been elected Vice-President of Taylor Turbine Corporation. He had been Manager of the Sales Research Division of Wright Aeronautical Corporation.

Oscar A. Rothschild has joined the Engineering Staff of Chance Vought Aircraft Division, United Aircraft Corporation.

John B. Scalzi has joined the faculty of the Case School of Applied Science as Professor of Structural Engineering. His previous association has been with Curtiss-Wright Corporation.

Oscar Shapiro has become a Stress Analyst at Republic Aviation Corporation.

Lt. Col. Harold W. Sibert has joined the faculty of the University of Colorado as Professor of Aeronautical Engineering.

Colwert P. Simonds has returned from active duty with the U.S. Army Air Forces and is now an Aeronautical Engineer at Consolidated Vultee Aircraft Corporation.

Larz McC. Smith has joined the Columbus Plant of the Curtiss-Wright Corporation as a Structures Engineer. He had been with the Waco Aircraft Company.

Walter C. Stempel, recently discharged from the U.S. Navy, is now a Junior Aerodynamicist at Northrop Aircraft, Inc.

Eugene D. Sullivan has been appointed Manager of the West Coast office of the Propeller Division of Curtiss-Wright Corporation.

Earl J. Swailes, formerly of The Glenn L. Martin Company, is now Operations Manager of Goodwill Industries.

Juan T. Trippe, President of Pan American World Airways System, has been elected a Member of the Board of Directors of the Commerce and Industry Association of New York.

Juan T. Trippe.

John C. Truman has returned from active duty with the U.S. Army Air Forces and is now an Instructor in the Department of Physics at Rensselaer Polytechnic Institute.

Donald D. Warner has joined North American Aviation, Inc., as a Stress Analyst. He had previously been with The Glenn L. Martin Company.

John M. Warner, formerly of Vickers-Armstrongs, Ltd., is now an Analysis Engineer with British European Airways (England).

John R. Weske has joined the faculty of Purdue University as Professor of Aeronautical Engineering, in Charge of the Division of Aerodynamics. He had been on the faculty of Rensselaer Polytechnic Institute.

Bernard A. Wiener has become Head of the Structural Dynamics Section, Bureau of Aeronautics, Navy Department.

Wayne Wiesner has joined United Helicopters, Inc., in Charge of Aerodynamics and Stress Analysis.

Salvatore X. Xifo is now a Flight Test Engineer at The Glenn L. Martin Company. He has recently returned from Navy duty.

Samuel Yudewitz, formerly with Curtiss-Wright Corporation, has joined Republic Aviation Corporation as a Senior Stress Analyst.

Sing-fuh Yui is now an Aerodynamicist at North American Aviation, Inc. He had previously been associated with Consolidated Vultee Aircraft Corporation.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Transferred to Associate Fellow Grade

Bogert, Reid, B.A.; Project Engineer, Douglas Aircraft Co., Inc.

Haller, George Louis, Ph.D. in Physics; Asst. Dean, Chem. and Physics, Pennsylvania State College.

Elected to MEMBER Grade

Baranowski, John Joseph, Ae.E.; Commander, Head of Air Section, U.S. Navy.

Barker, Edward Harman, B.S. in Ae.E., Head of Pure and Applied Science Dept., Parks Air College.

I.A.S. Meeting Preprints

A limited number of copies of preprints of papers presented at meetings of the Institute are available for distribution, at a charge of 25 cents each to members of the Institute, and 50 cents to non-members, to cover handling and mailing charges. The following lists preprints available from the past four national meetings of the Institute. Preprints may be ordered by number.

Fourteenth Annual Meeting—New York, N.Y., January 29–30–31, 1946

2. Higher Modes of Vibration by a Method of Sweeping—L. Beskin, Design Specialist, Consolidated Vultee Aircraft Corporation, and R. M. Rosenberg, Consulting Engineer, Purdue University. 38 pages; 7 illus. (Ditto.)

3. The Determination of Airspeed System Errors—Herbert R. Crawford, Chief Flight Test Engineer, Grumman Aircraft Engineering Corporation. 68 pages; 13 illus. (Typewritten and photo-offset.)

4. Trouble Shooting with Vibration Equipment—Harold Vern Hawkins, Vibration Engineer, Bell Aircraft Corporation. 37 pages; 13 illus. (Typewritten and photo-offset.)

5. The Development of a High-Temperature Light-Weight Insulation for Jet Aircraft—Donald Jelinek, Mechanical Research Engineer, North American Aviation, Inc. 26 pages; 22 illus. (Ditto.)

6. Safety Beyond Regulatory Requirements—W. E. Koneczny, Safety Bureau, Civil Aeronautics Board. 25 pages; no illus. (Mimeographed.)

7. Force Measurements by Means of Resistance Wire Strain Gages—W. C. Randels, Aeronautical Engineer, North American Aviation, Inc. 7 pages; 7 illus. (Typewritten and photo-offset.)

8. Considerations in the Design of a Low Cost Wind Tunnel—Howard E. Roberts, Aerodynamics Engineer, Douglas Aircraft Company, Inc. 46 pages; 12 illus. (Typewritten and photo-offset.)

9. Hydraulic Motors and Their Application to Aircraft—James Robinson, Assistant Chief Engineer, Vickers Incorporated. 4 pages; 6 illus. (Vari-typed and photo-offset.)

10. Systematic Wing Section Development—George S. Schairer, Chief Aerodynamicist, Boeing Aircraft Company. 14 pages; 14 illus. (Mimeographed with photostats of illustrations.)

11. Measurement of Steady and Vibratory Stresses in Aircraft Propellers—E. F. Shelley, Project Engineer, Propeller Division, Curtiss-Wright Corporation. 8 pages; 9 illus. (Mimeographed with ditto illustrations.)

13. The Organization and Utilization of an Aircraft Manufacturer's Air Safety Program—Amos L. Wood, Chief, Accident and Operations Analysis, Boeing Aircraft Company. 9 pages; 14 illus. (Mimeographed with photostats of illustrations.)

Aircraft Propulsion Meeting—Cleveland, Ohio, March 21, 1946

15. Application of Axial Compressors in Aeronautics—Ens. F. J. Gardiner, United States Naval Reserve, Navy Department, Bureau of Aeronautics. 11 pages; 8 illus. (Typewritten and photo-offset.)

Light Aircraft Meeting—Detroit, Mich., June 13–14, 1946

16. Effect of Center of Gravity Movement on Safety of Personal Aircraft—J. M. Gwinn, Jr., Chief Engineer, Personal Aircraft Engineering, Consolidated Vultee Aircraft Corporation. 12 pages; 5 illus. (Mimeographed.)

17. Optimum Seating Arrangements for Light Airplanes—Frederick K. Teichmann, Professor of Aeronautical Engineering, Chairman, Department of Aeronautics, Daniel Guggenheim School of Aeronautics, New York University. 7 pages; no illus. (Mimeographed.)

18. Maintenance of Personal Aircraft—George H. Weitz, Chief, Air Frame Section, Non-Scheduled Aircraft Maintenance Division, Civil Aeronautics Administration. 7 pages; no illus. (Mimeographed.)

Annual Summer Meeting—Los Angeles, Calif., July 18–19, 1946

20. Engineering Aspects of the Development of the Rainbow—Alexander Kartveli, Vice-President and Chief Engineer, Republic Aviation Corporation. 68 pages; 61 illus. (Vari-typed and photo-offset.) *Available without charge from Republic Aviation Corporation.*

23. Current Problems in Developing Major Components for Aviation Gas Turbines—Arnold H. Redding, Section Engineer, Flow Research Development and Research Engineering, Westinghouse Electric Company. 19 pages; no illus. (Mimeographed.)

24. A Concept of Jet Aircraft Utilizing Boundary Layer Air for Propulsion—A. M. O. Smith, Preliminary Design Aerodynamicist, and Howard E. Roberts, Aerodynamic Engineer, El Segundo Engineering Division, Douglas Aircraft Company, Inc. 44 pages; 17 illus. (Photo-offset.)

25. Design and Development of the Douglas B-42—Carlos C. Wood, Head of Preliminary Design, Santa Monica Engineering Division, Douglas Aircraft Company, Inc. 9 pages; 21 illus. (Photo-offset.)

Bates, Curtis Lemon, B.Ae.E.; Design Administrator, Northrop Aircraft, Inc.

Beman, Ward Wilson, B.Sc.; Chief of Aeronautical Research Div., Lockheed Aircraft Corp.

Biglow, James Otis, M.S.; Commander, U.S. Navy.

Bostock, Sidney Herbert, Managing Director and Chief Designer, Research Associates (England).

Bottenberg, William Robert, B.S.; Lt. Comdr., Sr. Power Plants Engineer, U.S. Navy.

Buchner, George Harold, B.S., B.A.; Chief, Service Engineering, Douglas Aircraft Co., Inc.

Church, Arthur Stanford, M.S.; Aerodynamics Engineer, Douglas Aircraft Co., Inc.

Cloukey, Malcolm Mather, B.A.; Capt., Asst. Director, Inspection Division, Bureau of Aeronautics, Navy Dept.

Coates, Leonides Dixon, M.S. in Ae.E.; Executive Asst. to Asst. Chief, Bur. Aer. for Research, Navy Dept.

Cone, Howard Maurice, Jr., B.S. in Ae.E.; Master Pilot, Pan American Airways System.

Cook, Glenn Edward, Field Service Engineer, Sperry Gyroscope Co., Inc.

Dawson, Vincent, Design and Development Engineer (Power Plants), Canadair Ltd. (Canada).

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Grimaud, Raymond, Director Methods, Societe Nationale de Construction Aeronautiques du Sud-Est (France).

Hege, Jeremiah Collins, M.S. in Aeronautics; Capt., Asst. Chief, Stress Analysis Unit of the Structures Branch, Aircraft Lab., Engineering Div., U.S. Army Air Forces.

Johnson, Norman Edwin, M.A.; Flight Test Analyst, North American Aviation, Inc.

Lutz, Charles Henry, Ph.D.; Lt. Col., U.S. Army Air Forces.

Martin, Robert William, B.S. in M.E.; Engineering Designer, Douglas Aircraft Co., Inc.

Noland, Thomas J., Jr., M.S.; Stress Analyst "A," North American Aviation, Inc.

O'Brien, Frank Edwin, B.S.; Flight Engineering Inspector, Dept. of Commerce, C.A.A.

Piattelli, Fidia James, Dr. in Ae.E., A.F.R.Ae.S.; General Manager and Chief Engineer, MAOF Palestine Aircraft Co. Ltd. (Palestine).

Plesset, Ernst Haeckel, Ph.D.; Research Mgr.—Research Labs., Douglas Aircraft Co., Inc.

Rembleske, Chester Anthony, B.S. in Ae.E.; Lt. (j.g.), Structural Engineer, U.S. Navy.

Roehm, Jack Moody, M.S. in E.E.; Director of Engineering, Buehler & Co.

Shaw, Spencer Loraine, B. of Naval Sciences; Structures Engineer, El Segundo Div., Douglas Aircraft Co., Inc.

Shogran, Ivar Leonard, Chief, Power Plant Section, Douglas Aircraft Co., Inc.

Shunker, Percival Edwin Quintin, B.Sc.; Sr. Structures Engineer, Airspeed Ltd. (England).

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Troke, Robert Woodrow, B.A.; Laboratory Analyst B—"Test Engineer," Douglas Aircraft Co., Inc.

Webb, Leland Dotson, M.S.; Capt., Supervising Inspector of Naval Material, Los Angeles District, U.S. Navy.

Wheelon, Orville Albert, B.S. in M.E.; Production Engineer, Douglas Aircraft Co., Inc.

Whitesides, William Frank, B.S. in M.E.; Power Plant Design Supervisor, Douglas Aircraft Co., Inc.

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Crispin, Charles H., administrative position, Office of Instruction Material, Escola Técnica de Aviação (Brazil).

Forsten, Irving, B.Ae.E.; Aeronautical Engineer (Induction Aerodynamics Lab.), Langley Mem. Aero. Lab., N.A.C.A.

Gilmer, George Walker, III, B.M.E.; Supervisor of Maintenance Production, American Airlines, Inc.

Heald, Ervin Ross, B.S. in Ae.E.; Aerodynamic Engineer, Douglas Aircraft Co., Inc.

Plommer, William Douglas, Ae.E.; Structural Designer, East Coast Aeronautics Inc.

Elected to Industrial Member Grade

Cochran, Douglas Lessel, M.B.A.; Asst. to Administrative Engineer, Douglas Aircraft Co., Inc.

Fonell, James Vincent, Founder and Dean, Pan American Academy of Aeronautics, Inc.

Kulesh, Eugene Weldon, Chief Estimator, Republic Aviation Corp.

Peale, Mundy Ingalls, Ph.D.; Vice-President, Republic Aviation Corp.

Elected to Technical Member Grade

Anderson, Karl Manfred, Engineering Designer "B," Douglas Aircraft Co., Inc.

Batlas, Christie, Layout Draftsman, Westinghouse Electric Corp., and General Manager, State Model Co.

Bogatto, William, Instructional duties, British Overseas Airways Corp. (England).

Dastur, Jehangir C., Ground Engineer, Bombay Flying Club Ltd. (India).

Dixon, Howard Henry, B.S. in E.E., Ae.E.; Aerodynamicist, Douglas Aircraft Co., Inc.

Gannon, Thomas Francis, Technical Planner, Canadair Ltd. (Canada).

Gardinier, Harold Edward, Engineering Checker, Canadair Ltd. (Canada).

Hartline, Paul Arnold, B.Ae.E.; Major Detail Draftsman, Republic Aviation Corp.

Hopkins, Richard Marshall, B.S. in M.E.; Design Engineer, Consolidated Vultee Aircraft Corp.

Hurlburt, Harvey Leslie, B.S.; Research Engineer, Republic Aviation Corp.

Marcus, Raphael A., Technical Writer, Canadair Ltd. (Canada).

Transferred from Student to Technical Member

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Beek, Charles Robert, B.Ae.E.

Burke, Donald Edward, S.B.

Crockett, David Williams, B.S. in Ae.E., M.E.; Flight Test Engineer, Chance Vought Aircraft Div., United Aircraft Corp.

Douglass, Melvin L.

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Evanson, Robert Merrill, B.S. in Ae.E.; Mathematician "B," North American Aviation, Inc.

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Osborne, James Insley, Jr., B.S.; Detail Engineer, Boeing Aircraft Co.

Packard, Bruce H.

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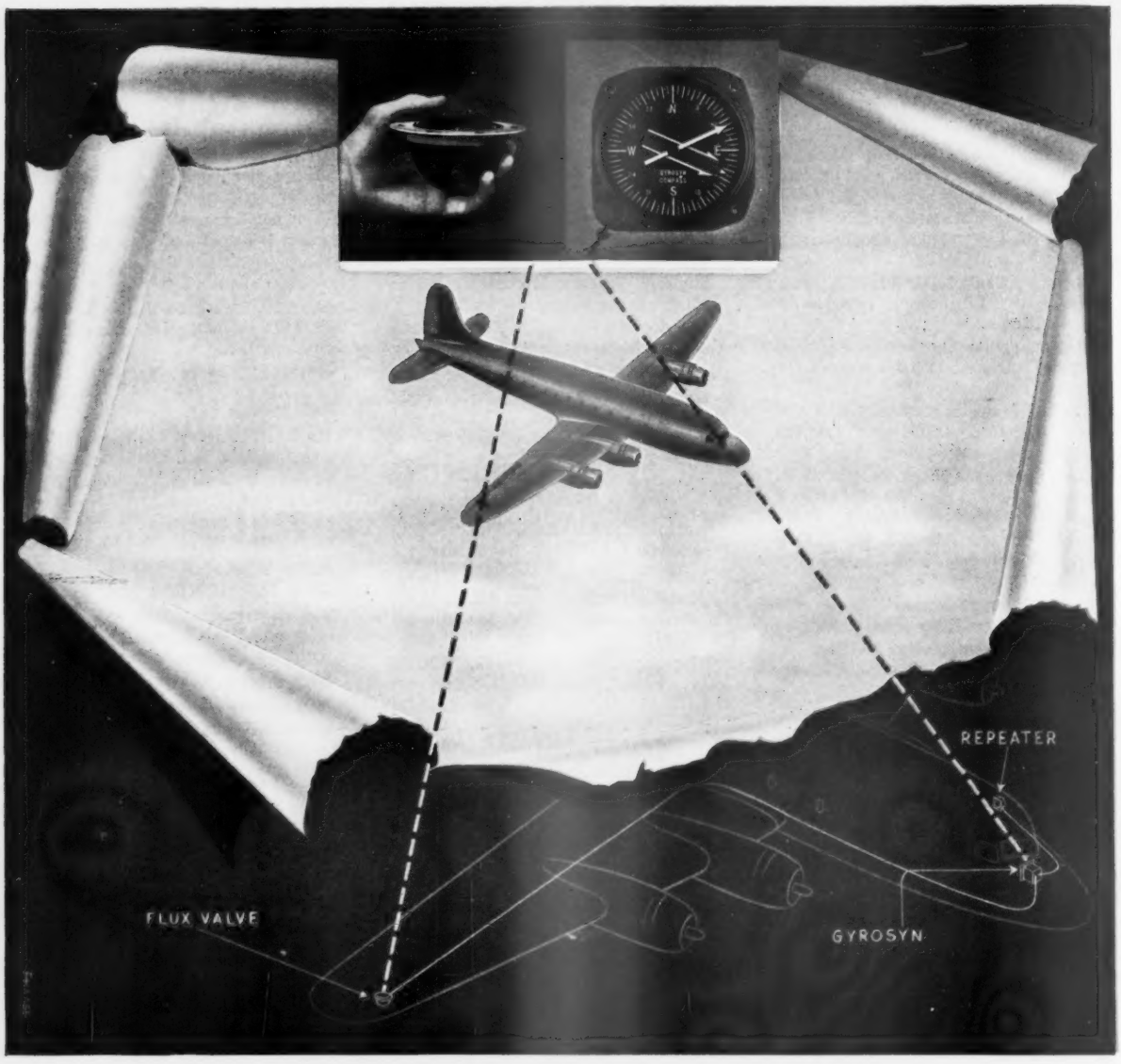

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Stephens, Robert Russel, B.Ae.E.; Aerodynamicist, McDonnell Aircraft Corp.

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Zell, John Hurster, M.S. in Ae.E.; Major—Chief, Aircraft Section of Technical Intelligence, U.S. Army Air Forces.

Zuckerman, Irving, B.Ae.E.; Jr. Stress Analyst, The Glenn L. Martin Co.

Necrology

William Harrison Dudley

William Harrison Dudley, Pacific Coast Executive of the Institute and an Industrial Member, died in Los Angeles on September 1.

Born in Baltimore, Md., on May 7, 1894, Mr. Dudley attended the Baltimore Law School of the University of Maryland. From 1914 to 1918 he was Executive Secretary to the Governor of Maryland, in charge of public and press relations. In 1918 he became Secretary of a mission to Russia. From 1921 to 1927 he was engaged in various New York business enterprises in an executive capacity, and in 1928 he became Treasurer of the Metal Airplane Company. From 1929 to 1934 he was President and General Manager of a drug manufacturing company, and in 1935 he acquired sole proprietorship of this business. He joined the Southern California War Finance Committee in 1941, arranging and presiding over meetings in behalf of War Bond drives. In 1945 he entered the service of the Institute to manage its interests on the Pacific Coast.

Alexander Russell Stevenson, Jr.

Alexander Russell Stevenson, Jr., Staff Assistant to the Vice-President in Charge of Engineering at the General Electric Company and a Member of the Institute, died at Ellis Hospital in Schenectady, N.Y., on August 28.

Born in Schenectady on May 28, 1893, Dr. Stevenson received a C.E. degree from Princeton University in 1914, and from Union College the degrees of M.S. in 1915 and Ph.D. in 1917. In World War I he was First Officer in Charge of Testing at Langley Field during the summer of 1917, and from November, 1917, to March, 1918, was Officer in Charge of the Radio and Electrical Section of the Air Service in the A.E.F. From 1919 to 1923 he was a member of the Power and Mining Engineering Department at the General Electric Company. He assisted in the establishment of an advanced course in engineering at the company in 1923, and since 1930 had had complete charge of this educational program.

Dr. Stevenson was a member of the special subcommittee on jet propulsion of the National Advisory Committee for Aeronautics from 1941 to 1944. He was a member of the Civilian Advisory Council, Military Training Division, Ordnance Department, since 1942, and an advisory member of the New York State Aviation Council.

I.A.S. National Meeting Schedule

Tenth Wright Brothers Lecture—Washington, D.C.—December 17, 1946

Fifteenth Annual Meeting—New York, N.Y., Hotel Astor —January 28–29–30, 1947.

Aircraft Propulsion Meeting—Cleveland, Ohio—March, 1947

The Meetings Committee of the Institute invites participation in the technical sessions of the meetings of the Institute.

Members or organizations wishing to submit papers for these meetings should send complete papers, or outlines or summaries, to the Meetings Committee at least three months prior to the meeting. Outlines or summaries should not exceed 1,000 words.

All papers submitted will be considered for publication in the *Journal of the Aeronautical Sciences* or the *Aeronautical Engineering Review*.

All correspondence should be addressed to The Meetings Committee, Institute of the Aeronautical Sciences, 2 East 64th Street, New York 21, N.Y.

CLIPPER
2047

Editorial

Cooperation vs. Competition

Air-line operation is becoming more and more an engineering activity. Back in the days of seat-of-the-pants flying, the success of an air-transport line depended primarily on the ability (and sometimes the luck) of the pilots to get machines into the air and to their destinations, with little or no help. Now, however, with aircraft of the size and complexity of the Skymaster, the Mars, or the Constitution, and with operations as complicated as they are, pilots not only need a high degree of engineering understanding themselves, but must also rely heavily on the services of engineering personnel on the ground and on the flight deck with them.

The increasing importance of the trained engineer to the air line is reflected in the rosters of air-transport organizations. A dozen years ago, the heads of maintenance and operations departments were, more likely than not, men who had come up through the ranks as mechanics and as pilots. Today, to an ever increasing degree, it takes a man who has had the training and discipline implied by an engineering degree to handle such jobs effectively. The airplanes now in service are vastly complicated bits of machinery, and it takes more than an understanding of their essential mechanisms to handle them safely and efficiently.

Modern air-line operation involves many fields outside the strictly aeronautical. Passengers must be comfortably housed and seated, and they must be fed from time to time. Radio communication with the ground must be maintained. Complicated navigational problems must be met and solved. Efficient and economical fuels and lubricants must be selected. These, and a host of other questions, although on the fringes of aeronautical engineering proper by strict definition, nevertheless are of great interest to most I.A.S. members and do have a considerable bearing on their work.

It is because of the need for a greater understanding of the engineering problems in which air lines are involved that the Institute has included in its program an annual meeting given over entirely to discussion of such subjects. The fourth such meeting will be held in Washington shortly after this issue appears. The intention is to provide a forum in which the engineering representatives of the operators and the aircraft and engine manufacturers may consider the broader aspects of the constantly shifting problems of design for efficient operation which confront them.

It is clearly impossible for any one professional society to cover all fields adequately. We can, however, by working cooperatively with other groups whose primary interests are in other activities, bring combined experience to bear for the mutual benefit of all concerned. As a move in that direction, the I.A.S. National Air Transport Meeting is being held this month in Washington in conjunction with a meeting of the Institute of Navigation. Members of each society are welcome to attend either meeting. One joint technical session is scheduled, and the banquet on October 24 is a cooperative affair.

This is the sort of "combined operation" that should be undertaken more often by the several professional societies. If each tries to be completely self-sufficient, it will spread its effort so thin that the effectiveness of services to its membership may be seriously reduced. Competition among professional societies leads only to wasteful duplication of effort and to confusion among their members. The Institute will welcome any suggestions from its members or from other societies which will promote cooperation rather than competition.

Maintenance of modern aircraft is an Engineering job of a high order

Flying Qualities Requirements for Military Aircraft*

MALCOLM J. ABZUG†

Bureau of Aeronautics

Introduction

THE ESTABLISHMENT of formal flying qualities requirements for military aircraft by the Army and Navy has taken place entirely during the war years. Therefore, it is only recently that it has become possible to make these requirements generally available. Because of our constantly expanding theoretical and experimental knowledge of airplane flying qualities, the requirements can remain vital and significant only through periodic revisions. It is believed that general discussion can materially aid in these necessary periodic revisions.

MALCOLM J. ABZUG.

Current Requirements

The current flying qualities requirements for military aircraft appear in two Army and Navy specifications.[1,2] These specifications do not attempt to present the background. A brief outline of the current requirements for military aircraft is presented below, together with such discussion of background material as may be of general interest.

Control System

The static friction forces of the primary controls, measured at the points of application of pilot effort, are required to be within the limits of Table 1.

The limits of Table 1 were established by correlation of Navy test pilots' opinions with the results of friction measurements on the ground on 18 airplanes of various types. These measurements and opinions are summarized in Table 2.

From the data of Table 2, the limits of acceptable control friction were found to have no valid correlation

TABLE 1

Control Friction Limits, Pounds

Control	Airplanes with Stick-Type Controls	Airplanes with Wheel-Type Controls
Elevator	3	8
Rudder	7	15
Aileron	2	6

TABLE 2

Control Friction Data

Airplane Type	Gross Weight (Lb)	Wing Span (Ft)	Measured Control Friction, Pounds (At neutral position of control) Elevator 0 5 10	Rudder 0 10 20	Aileron 0 5 10
STICK-TYPE CONTROLS					
Carrier Fighter	6100	36.1	○	○	◐
Carrier Fighter	6800	36.8	○		●
Carrier Fighter	7600	38.0	○	◐	●
Catapult Scout	8000	41.0	◐	●	◐
Carrier Bomber	9200	42.0	◐	◐	◐
Fighter	10200	49.0	●	●	●
Carrier Fighter	11400	41.0	◐	◐	○
Carrier Bomber	11700	48.5	◐	○	○
Carrier Fighter	11800	41.0	○	◐	○
Carrier Fighter	11900	42.8	◐	○	●
Carrier Fighter	12400	42.8	◐	○	◐
Carrier Bomber	15200	49.8	●	●	●
Carrier Bomber	15500	54.2	●	●	●
Carrier Fighter	22000	51.5	●	●	●
			Elevator 0 10 20	Rudder 0 20 40	Aileron 0 5 10
WHEEL-TYPE CONTROLS					
Bomber	26500	65.5	◐	◐	◐
Flying Boat	56000	118.0	○	◐	○
Bomber	63500	110.0	●	●	◐
Flying Boat	66000	115.0	●	●	●

Pilot's opinion: ○ Light ◐ Acceptable ● Too high

Presented at the Summer Annual Meeting, I.A.S., Los Angeles, July 18–19, 1946.

* The opinions expressed herein are those of the author and do not necessarily reflect those of the Navy Department.

† Lieutenant, U.S.N.R., Flying Qualities Specialist, Aerodynamics and Hydrodynamics Branch. Now, Aerodynamicist, Douglas Aircraft Company, Inc.

with any airplane characteristic but the type of control used, stick or wheel.

Static Stability

Static stability about all three major axes is required for military aircraft in seven configurations over certain speed ranges. These specified flight conditions represent typical nonemergency operating conditions for military aircraft, in which flight for appreciable periods of time is expected. The seven specified flight configurations are summarized in Table 3.

Positive static longitudinal, directional, and lateral stability with controls both fixed and free are required for these configurations, over most or all of the permissible speed range in each configuration, with some minor exceptions. In addition, a minimum amount of static directional stability and an upper limit to static lateral stability are specified.

TABLE 3

Airplane Configurations for Which Static Stability Is Required

Configuration	Flaps and Landing Gear	Power (Power set at Given Trim Speed and Power Controls Held Fixed Over Speed Range)	Remarks
Approach	Down	50 percent normal rated	Not required for ship-based aircraft
Cruise	Up	For level flight at speed for maximum range	
Dive	Up (unless used as dive brakes)	25 percent normal rated	Dive braking devices in operation. Not required for light aircraft, transports, etc.
Glide	Up	Off (Throttle closed)	
Landing	Down	Off (Throttle closed)	
Power-on Clean	Up	Normal rated	
Power Approach	Down	For level flight at 15 percent above stalling speed in Landing Configuration	Required only for ship-based aircraft.

Dynamic Stability

Required amounts of damping are specified only for the inherently shorter period modes of periodic motion of the airplane. In no case are limits for the period of any motion specified. Complete damping of all control surfaces in one or two cycles is required when the controls are individually abruptly deflected and released, since the short-period coupled motions of the airplane and controls are inherently quick motions. In addition, damping of the control-free lateral oscillation (Dutch-roll) to one-half amplitude in two cycles is required.

Control Power

Control power requirements are specified in terms of required airplane maneuvers. Sufficient control power (effectiveness) is required to allow the airplane to perform the maneuvers listed in Table 4.

For each maneuver listed the power of some specific control or controls is generally critical, as indicated in Table 4. In the Army and Navy flying qualities specifications, the required maneuvers are actually specified as design conditions to be met by the particular critical control or controls.

TABLE 4

Control Power Requirements

	Maneuvers Required of Airplane	Critical Control
1	Balance in steady flight with wings level over speed range	Elevator Rudder
2	Develop maximum lift coefficient or positive limit load factor over speed range	Elevator
3	Power-off landing at most forward c.g.	Elevator
4	Secure thrust line level attitude for take-off at aft c.g. (tail-wheel gear)	Elevator
5	Raise nose wheel for take-off at forward c.g. (nose-wheel gear)	Elevator
6	5 degree sideslip in approach for landing (ship-based aircraft)	Rudder
7	Maintain straight ground part in take-off	Rudder
8	Maintain straight ground path in landing	Rudder
9	Taxi satisfactorily	Rudder
10	Hold zero sideslip with asymmetric power	Rudder Ailerons
11	Hold zero sideslip in a roll with full aileron deflection	Rudder
12	Recover from spins	Rudder
13	Develop rolling acceleration in specified time	Ailerons
14	Roll at specified value of pb/2V	Ailerons
15	Prevent or recover from complete stall	Elevator Rudder Ailerons

Control Forces

Several values for maximum acceptable elevator control forces are specified, depending on the flight conditions involved. These values are summarized in Table 5.

The values for maximum acceptable elevator forces in accelerated maneuvers (turns and pull-ups) were derived from the N.A.C.A.'s findings that 8 lbs. per *g* for fighter-type aircraft (with stick-type controls) and 50 lbs. per *g* for bomber and transport aircraft (with wheel-type controls) represented the maximum values that were considered acceptable by N.A.C.A. pilots. For the aircraft trimmed for zero elevator control force at one g and for positive limit load factors of 8.00 and 2.67 for the fighter and bomber aircraft, respectively, maximum acceptable elevator forces of 56 lbs. for a stick-type control and 83.5 lbs. for a wheel-type con-

TABLE 5

Maximum Acceptable Elevator Control Forces

Flight Condition	Relative Time of Application of Force	Maximum Acceptable Elevator Force, Pounds	
		Stick	Wheel
Emergency 3 g pullout at high Mach numbers	Short (both hands considered available)	150	150
Accelerated maneuvers (turns and pullups) for dive bomber airplanes with rearward-firing guns	Short	84	125
Accelerated maneuvers (turns and pullups)	Short	56	83.5
High speed dives, trimmed for level flight	Long	$(n-1)F_n$ *	$(n-1)F_n$ *
Landing and trim changes due to power, flaps, landing gear and dive brakes	Short	35	50

* n is positive limit load factor, F_n is elev. control force gradient, pounds per g.

trol to reach the positive limit load factor are indicated. The opinions of service pilots have confirmed these limits in the majority of cases. Larger elevator control forces are allowed in accelerated maneuvers for dive-bomber aircraft with rearward-firing guns because it is considered that these aircraft are maneuvered close to their positive limit load factor only once or twice in each operational flight.

Maximum acceptable rudder and aileron control forces are expressed in similar terms and are summarized in Tables 6 and 7, respectively.

Minimum acceptable control force values can be used to prevent overloading of the structure through over-control by the pilot and to insure reasonably self-centering characteristics of the controls.

TABLE 6

Maximum Acceptable Rudder Control Forces

Flight Condition	Relative Time of Application of Force	Maximum Acceptable Rudder Force, Pounds
Take-offs, landings, overcoming adverse yaw in rolls, spin recovery and asymmetric power (engine failure after take-off)	Short	180
High speed dives, trimmed for level flight	Long	100

TABLE 7

Maximum Acceptable Lateral Control Forces

Flight Condition	Relative Time of Application of Force	Maximum Acceptable Lateral Control Force, Pounds	
		Stick	Wheel
Rolls with rudder locked and asymmetric power (engine failure after take-off)	Short	30	80
High speed dives, trimmed for level flight	Long	10	15

Minimum elevator control force gradients are specified in the flying qualities requirements to prevent destructive values of normal acceleration from being easily attained, but no minimum rudder or lateral forces are specified. Instead, self-centering of these controls is required directly.

Trim Changes

Upper limits to the trim changes at constant speed due to changes in flap, gear, power, or dive-brake setting are specified. Of the possibilities for specifying limits on the force and deflection changes of all three controls, only an elevator force limit is established, since the other force and deflection changes have not usually been large enough to be detrimental to flying qualities. A series of 13 arbitrary flap, gear, power, and dive-brake setting changes are prescribed for investigating the elevator force trim change.

Trimming Devices

Like the control power requirements, the requirements for the power of trimming devices are expressed in terms of maneuvers or flight conditions that are required of the airplane. No correlation of flight measurements with pilot's comments is available to support the requirements for the power of trimming devices. The airplane configurations and speed ranges for which trim for zero control forces is required have been arbitrarily established as approximations to the requirements of service pilots.

Stall Characteristics

Flight characteristics in the approach to and the recovery from the complete stall are specified. No requirements are placed on the behavior of the airplane in the complete stall.

NEW REQUIREMENTS

The present flying qualities requirements for military aircraft are the result of many years of research and development. It is considered that all of the really fundamental requirements for satisfactory flying qualities for military aircraft are covered therein. For the near future, therefore, it appears that any new or revised requirements that are established will not involve any major departures from the present document.

It is expected that new or revised requirements will evolve largely from flight experience on specific airplanes that show unsatisfactory flying qualities that had not been experienced before.

Another source of new or revised requirements is expected to be theoretical studies (eventually supplemented by flight experience) which predict difficulties not yet experienced.

A third source of new flying qualities requirements is obviously the fluid tactical requirements for military aircraft, which may demand, for instance, increased rates of roll for bombers.

Actual examples of proposed new flying qualities requirements from all three sources, flight experience, theory, and tactical needs will be presented below. The numerical values used in these proposed requirements are considered as approximations, since generally more extensive correlation of flight-test measurements and pilot's opinions are needed to establish definite criteria.

It is hoped that these examples will demonstrate how new and revised flying qualities requirements are developed and will also stimulate discussion and research on the specific flying qualities involved.

Proposed Lateral Oscillation Requirement

Any combat military aircraft must be capable of being flown with great steadiness at some speeds for gunnery, bombing, torpedoing, mapping, or observation. Steadiness is also desirable for take-offs and landings. For steadiness, the natural oscillations of an airplane must be either self-damped, so as to disappear a short

while after disturbances, or be capable of being quickly damped by action of the pilot's controls. The latter possibility requires that the natural period of the oscillations be sufficiently long so that the normal lag in the pilot's reactions will not cause him to reinforce the oscillations when he is attempting to damp them. These considerations lead to the general principle that the necessary amount of damping of any airplane oscillation varies with the period of the oscillation. For example, the fast oscillation of a free control surface must be well damped, while a slow oscillation such as the longitudinal phugoid need be only slightly damped, if at all.

The current lateral oscillation requirement specifies damping of the control-free lateral oscillation to $^1/_2$ amplitude in less than two cycles, regardless of the period of the oscillation. Damping that satisfied this requirement has been thought possibly inadequate on a recent airplane whose lateral oscillation period at high speed was short. Furthermore, the unusual combinations of stability derivatives which may be encountered on airplanes of the near future makes it desirable to rationalize the lateral oscillation requirements in accordance with the general principle stated above. Fig. 1 has been prepared to show the values for the period and damping of the lateral oscillation of some typical military aircraft. Also shown in Fig. 1 is a graphical presentation of a lateral oscillation requirement which specifies damping in terms of the period. In written form this requirement is, "The control-free lateral oscillation shall damp to $^1/_2$ amplitude in less than $0.4P + 0.8$ cycle, where P is the period of the lateral oscillation in seconds. If the period of the lateral oscillation is greater than 6 seconds, this requirement does not apply and damping is not required. This requirement shall be met in the configurations and speed ranges specified for the airplane in Table II."[1, 2] For periods greater than 6 sec., the lateral oscillation is considered to be like the longitudinal phugoid, so easily controllable as to require no natural damping.

Even though the damping of the lateral oscillation meets either the above or the existing requirements for large-amplitude oscillations, the existence of residual small-amplitude continuous oscillations would be considered as detracting from the necessary airplane steadiness and would be generally termed unsatisfactory. Such residual oscillations have been experienced on several U.S. and foreign military types, all at high speeds. For example, three of the airplanes for which data are given in Fig. 1 have continuous lateral oscillations at high speeds of amplitudes ranging from 0.2 to 0.7° of sideslip. The periods of these residual oscillations are the same as the periods of the normal control-free lateral oscillation (Dutch roll) at the same air speeds. Although the amplitudes quoted above appear to be small, the actual oscillation is perceptible to the pilots, and is objected to. Possible contributing causes of this residual oscillation are thought to be:

(a) Irregular flow in the region of the vertical tail.

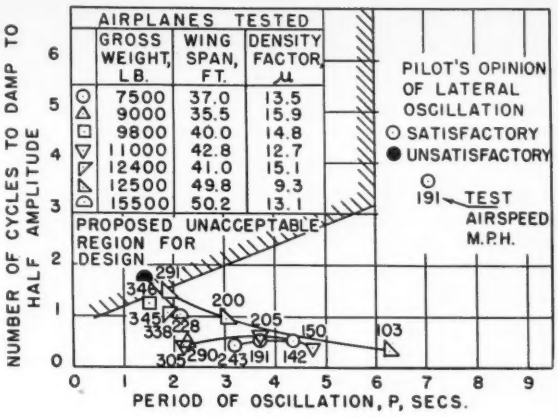

FIG. 1. Period and damping of the lateral oscillation.

(b) Low directional stability at small angles of sideslip.

(c) Power fluctuations on twin-jet aircraft.

(d) Fuel slopping in tanks.

Since we have not been entirely successful in preventing residual lateral oscillations on some airplanes, it is reasonable to consider establishing an upper acceptable limit for the amplitude of such an oscillation. Because of the small magnitudes of the motions involved, standard measurement procedures are generally inadequate, and the proposed requirement is based on the relation of the airplane to an external reference. "The amplitude of any steady control-free lateral oscillation shall be less than that required to produce a 3 mil* movement of a distant image when viewed through a forward-fixed gun sight in the airplane. This requirement shall apply to Class II, III, and IV airplanes in configurations P and D[1, 2] at speeds above the maximum level flight speed with normal rated power." Systematic flight measurements of this nature have not been made in this country on airplanes that are reported to have continuous small-amplitude lateral oscillations at high speeds, and the 3-mil upper limit quoted is taken from a German investigation.

Proposed Spiral Stability Requirement

For the same reason that airplane oscillations of long period need not be well damped, if at all, a divergent motion of an airplane may be acceptable provided that the rate of divergence is extremely slow. For the ranges of airplane stability derivatives which have been used in recent years, the spiral motion of airplanes has usually been a relatively slow convergence or divergence and no requirement has been found necessary to limit the rate of spiral divergence. However, because of the unusual combinations of stability derivatives which may be encountered on airplanes in the near future, it is desirable at this time to review the spiral stability situation. In particular, an airplane with a wing that is

* A mil is an angle measurement used extensively in gunnery. It is the angle subtended by a 1-unit height at a 1,000-unit distance.

swept-forward for high-speed flight will exhibit a strong spiral divergence at low speeds with flaps deflected. A spiral stability requirement of the following form is proposed, "If an airplane is spirally unstable with the controls free, the time required to double in amplitude a disturbance from trim in bank or sideslip shall not be less than 1 second, with the controls free. This requirement applies to the flight conditions of Table II."[1, 2]

One second was chosen as a proposed design upper limit for the rate of spiral divergence because this rate of divergence was found to represent the maximum for satisfactory flight characteristics in a systematic free-flight model investigation in the N.A.C.A. Free Flight Tunnel. The results of this N.A.C.A. investigation which pertain to this subject are summarized in Fig. 2. Spiral divergence caused poor flight behavior in the N.A.C.A. Free Flight Tunnel (rating C of Fig. 2) when the controls had to be applied quickly after the start of a spiral divergence was noted to prevent the rolling and yawing moments resulting from spiral instability from becoming sufficiently large to overpower the available control moments.

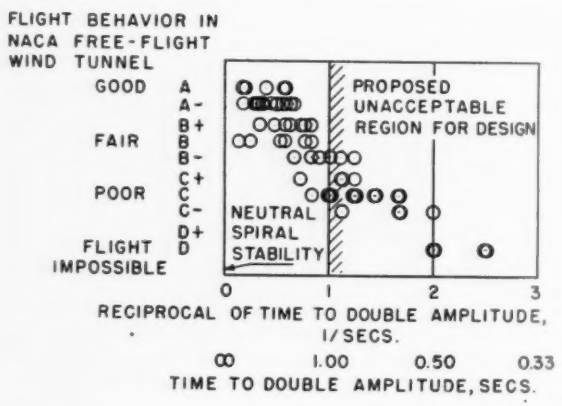

FIG. 2. Flight behavior with various rates of spiral divergence.

No information is available on the upper acceptable limit for the rate of spiral divergence in actual flight, since on airplanes that are flying this limit has apparently not been reached. It is of some interest to note that the German requirement for the upper limit of spiral divergence was much more rigid than the proposed limit quoted above. Their upper limit for the rate of spiral divergence was an increase of the amplitude of the disturbance by a factor of e (2.718) in 30 sec.

To secure a spiral divergence rate as high as the proposed limit, it is obvious that some negative control-free effective dihedral is needed. For a typical Navy fighter-type airplane, it is calculated that a negative effective dihedral angle of as much as $-7°$ would be needed at a lift coefficient of 2.0 to secure a spiral divergence rate of double amplitude in 1 sec. In general therefore, it can be stated that an airplane that will not meet the proposed spiral stability requirement also will not meet the existing requirement for positive control-free static lateral stability. The proposed requirement is still considered useful to define the permissible negative effective dihedral for design in cases where it is found expedient to waive the existing requirement for positive static lateral stability. Positive static lateral stability has often been found to be difficult to obtain, particularly on airplanes with swept-forward wings or on highly powered single-engined tractor airplanes at low speeds with flaps deflected and power on.

Proposed Stalling Characteristics Requirement

The stall maneuver may be said to consist of three stages—the approach, where the air speed is decreasing; the complete stall, where the airplane becomes laterally or longitudinally uncontrollable; and the recovery, where the pilot acts to resume normal flight. Present stall requirements cover the stall maneuver characteristics in the approach and in the recovery, but not in the complete stall. This treatment is based on the logical premise that if the airplane is controllable in the stall approach and adequate warning precedes the complete stall, there is no need to actually stall, and flight characteristics in the complete stall are of no consequence. Actual experience has not always supported this reasoning, since we have witnessed considerable amounts of development work on the complete stall characteristics of specific airplanes, aimed at preventing excessive wing dropping, diving, or altitude loss. One reason for this work seems to be that in carrier landings, the airplane may be stalled at a sufficient height above the deck so that a violent roll or dive in the complete stall would result in a bad landing. A proposed design requirement for flight characteristics in the complete stall is based on a correlation of measured maximum rates of initial roll-off in the complete stall with pilot's opinions of the stalling characteristics of several airplanes. This correlation is shown in Fig. 3, and the proposed requirement is, "In the initial roll-off in the complete stall, the airplane shall not roll with a rate exceeding 30 degrees per second, with either the controls fixed from the start

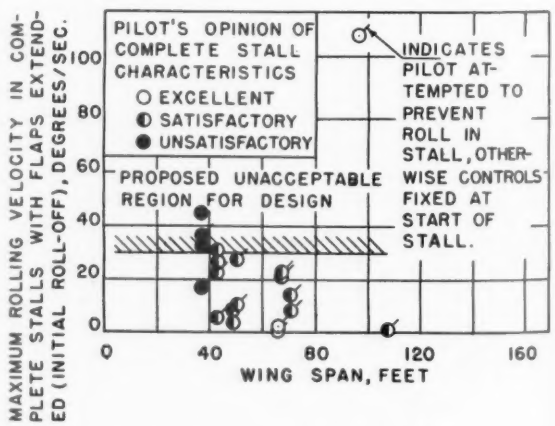

FIG. 3. Rolling velocities in the stall.

of the complete stall or with the controls used to minimize the roll. This requirement applies to stalls from straight flight in configurations L and A (L and PA for Class IV Airplanes)."[1, 2] As may be seen from Fig. 3, the correlation of measured values of rate of roll in the complete stall with pilots' opinions is not so conclusive as could be wished, since test points are available for only one airplane with unsatisfactory rolling tendencies. To take account of wide variations in wing span, a criterion giving a limit for the rate of roll as a function of wing span may be needed.

The maximum angle of bank attained in some short length of time, say 2 sec., after start of the complete stall is a more direct measure of the desired roll characteristics, since rates of roll of 30° per sec. and above would not cause large bank angles if the roll were oscillatory in nature, with sharp successive rolls to the right and left. This must be considered in arriving at a final stalling characteristics requirement.

It is not considered practical at this time to specify upper limits for rate of pitch and altitude loss in the complete stall.

Proposed Rate of Roll Requirement

The development of workable power boost for lateral control systems of small fighter aircraft has made possible extremely high rates of roll at high speed. Because of this fact it is desirable to have at hand a figure for design representing the maximum rate of roll considered usable by service pilots. This figure may limit the size and deflections of the ailerons on some airplanes, consequently limiting the size and weight of an aileron boost system, if provided, and the design air loads on the wing with deflected ailerons. Measured rates of roll on 14 U.S. and foreign fighter aircraft indicate that 140° per sec. is the maximum available rate of roll on any of these airplanes for either full stick deflection or 30 lbs. of lateral stick force. One hundred and forty degrees per sec. does not correspond to a practical upper limit for rate of roll, since the full amount of this rolling velocity is apparently useful tactically. On the other hand, higher values of rate of roll are expected for the near future, if they are not already attainable on airplanes that are flying. A proposed requirement is, "The maximum rate of roll attainable by full lateral control deflection or by lateral control forces of 30 pounds for a stick-type control or 80 pounds for a wheel-type control shall not exceed 270 degrees per second." The tentative limit of 270° per sec. quoted above can best be checked by service pilot's opinions on the lateral control power of airplanes that can attain rates of roll at least as great as this figure. The physical ability of a pilot to withstand continuously and to control accurately high rates of rotation will probably provide the limit on rate of roll. With the peak of available rate of roll occurring at speeds about midway between the stalling and limit diving speeds of the airplane, as is generally the case, this requirement would tend to limit the rate of roll at high diving speeds to less than the maximum usable rate, assumed to be 270° per sec. This possibly undesirable feature can be avoided by specifying that the rate of roll limit applies only to some high speed. A rate of roll of 270° per sec. is equivalent to the following values of the helix angle of roll $pb/2V$ at a true air speed of 500 m.p.h.:

Wing Span, Ft.	$pb/2V$ for Rate of Role of 270° per Sec. at 500 M.P.H.
30	0.10
40	0.13
50	0.16

These $pb/2V$ values are substantially above the specified lower limit of 0.03 at 500 m.p.h.[1, 2]

Other Proposed Requirements

Other flying qualities requirements for military aircraft which have been proposed cover a variety of characteristics. Some of these requirements are discussed below:

(a) *Lower Limit for Rudder Pedal Forces.*—A requirement may be necessary for the lower limit of the variation of rudder pedal force with sideslip angle in steady sideslips at constant air speed. One need for such a requirement arises from the possibility of obtaining destructively large angles of sideslip at high speeds by careless use of a light rudder. A requirement of this type which has been proposed places a lower limit of 5 lbs. of rudder pedal force per degree of sideslip at an indicated air speed of 150 m.p.h.

(b) *Gun Platform Requirements.*—The factors influencing the ability of an airplane to be accurately trained on a target, for fixed gunnery, have been extensively investigated in the past. The quality of an airplane as a "gun platform" is the term commonly used to describe this characteristic. Both larger and smaller than normal dihedral effect in gunnery runs have been suggested as necessary for a good gun platform. Large dihedral is suggested as a means of reducing the inadvertent sideslip in gunnery runs by making sideslip apparent to the pilot through large rolling moments. On the other hand, small dihedral effect has been suggested to reduce rolling due to aim corrections made by the rudder. No conclusive evidence is available to support either view, and airplanes that are considered to be good gun platforms have had both large and small effective dihedral. However, a good degree of directional stability, already specified in the current flying qualities requirements, is known to contribute to ease and accuracy of control at all speeds.

(c) *Spin Recovery Requirements.*—Specific design requirements for spin recovery are needed. Requirements for the number of turns of the spin before attempted recovery, the maximum number of turns for recovery, and maximum acceptable control forces for recovery for the various categories of military aircraft are already available in the form of flight demonstration requirements.

General

In addition to specific proposed flying qualities requirements, several general additions and revisions to the flying qualities requirements for military aircraft have been proposed and contemplated.

For example, the need for flying qualities requirements for helicopters has been apparent for some time. The N.A.C.A.'s experience in developing the fundamentals of the present requirements for fixed-wing aircraft[3, 4] should be a guide for this work. This would involve the determination of the factors that influence the flying qualities of helicopters, the measurement of these factors in flight on a number of helicopters, and the correlation of these measurements with pilot's opinions of the handling qualities of the machines.

Similarly, design requirements for the water handling characteristics of seaplanes and flying boats are needed. These requirements would presumably define acceptable values for the various types of hydrodynamic stability; porpoising, skipping, and directional stability on the water. The Bureau of Aeronautics is considering requirements of this type.

Finally, as in any work of its type, improvements in the flying qualities requirements are possible through minor changes in form and content leading to a clearer and more consistent presentation.

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[2] Anon., *Stability and Control Characteristics of Airplanes*, Army Air Forces Specification No. R-1815-A, April, 1945.

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[4] Gilruth, R. R., *Requirements for Satisfactory Flying Qualities of Airplanes*, N.A.C.A., April, 1941.

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Fighter Canopies

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Goodyear Aircraft Corporation

SUMMARY

The background of fighter canopy development is briefly reviewed and the inherent conflict between good aerodynamic contours and superior optics is discussed in some detail. Fabrication techniques utilized during the recent war are described and their limitations noted. The basic concern of this paper is a new and proved method for manufacturing canopies having both aerodynamic and optical excellence.

INTRODUCTION

THE FIGHTER AIRPLANE is first and last a flying gun platform designed to be efficient in its job of destruction. The effectiveness of this fighting machine is probably a maximum if, when meeting the contemporary enemy, its speed, range, maneuverability, weight, and precision of fire power, and ability to avoid or take fire power, are superior. These factors in the aircraft, coupled with the determination, skill, coolness, and fast reactions of its pilot, supply the margin required for victory. It is apparent that aerodynamic cleanness in the airplane and perfect vision for its pilot are of paramount significance in many of the preceding factors.

Confining ourselves to recent history, we find it fairly easy to trace the emphasis placed on good vision through fighter aircraft enclosures. The type of canopy common at the beginning of the war was made of relatively small flat glass or easily formed plastic panels usually of single curvature, held together in an elaborate framework. The panels themselves had excellent or fair optical qualities, depending upon the material, but the supporting framework contributed blind areas to the pilot's field of view. Much worse, however, was the bad rearward vision. The pilot's reaction was to demand some widening in the enclosure so that he might look to the rear. These demands were so strong in the English theater of operations that makeshift efforts provided some American fighters with a bulged panel that was substituted for a flat side panel. The pilot could stick his head into this bulge and peer backwards. Aerodynamicists were extremely unhappy about this. The first engineered attempts to improve pilot vision were aimed at eliminating some of the framework, which meant larger panels and compound curvature, then virtually impossible to achieve with good optics because of plastic molding problems.

A great step forward in the design of pilot enclosures was realized with the advent of the bubble canopy. Whereas previous enclosures had suffered from blind areas due to the supporting structure and from optical distortion due to molding, the bubble canopy eliminated these two sources of trouble by the straightforward process of using neither supporting structure nor mold. At the same time, the turtledeck was eliminated and the pilot was given full vision to the rear, as well as in all other directions except downward.

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OPTICAL REQUIREMENTS

Actual war service of our military airplanes and pilots has placed tremendous emphasis on vision in the interest of safety, combat effectiveness, and lowered fatigue. Pilots with combat experience have stated that

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there is no such thing as a permissible optical defect in a transparent enclosure. When a scratch will glint like a wing in the sun, a speck of dirt look like a plane in the distance, or distortion shows two where there is only one, we can understand such sweeping statements.

It has long been apparent that vision areas in military aircraft are of transcending importance. A British World War I pilot, J. B. McCudden, with 56 enemy planes to his credit, said in his book, *Flying Fury:* "It may sound absurd but such a thing as having dirty goggles makes all the difference between getting a Hun and not getting a Hun." Nowhere is the need for good vision more authoritatively presented than in a recent Wright Field Engineering Technical Note.[1] As this report puts it ". . . . the factor of surprise may affect the results of combat to a greater extent than the number of aircraft, performance of armament, and taking the enemy by surprise (or avoiding being taken by surprise) depends on the clearness of view through cockpit panels. With modern high-speed aircraft, only a few seconds advantage in spotting enemy aircraft first may mean the difference between combat success or failure. The record of this war is replete with accounts of Allied aircraft and ground installations attacked by our own planes and of enemy planes passed by or mistakenly identified. Recognition from a fast-moving plane in the air is an extremely difficult task. The differences between a Jap Tabby and a U.S. C-47, Zeke 52 and P-51, Jack and Navy F6F, and Takanami Class destroyer and U.S. Fletcher Class destroyer are very small and might easily be obscured by small spots of distortion.

"The requirement for good vision is not merely a recognition problem, because from take-off to landing, pilot and crew are affected by the optical qualities of the canopy. Cases of motion sickness and multiple-image vision, extraordinary fatigue, etc., have all been recorded." Again from the Wright Field Report: "Pilots flying the A-30 airplane were found to develop motion sickness from observing undulations of the horizon through distorted windscreens in low level flying. In the nose of the early B-17G's the complex curvature of the nose and the large angle of incidence to the front gunner's line of sight resulted in his seeing two targets instead of one in certain directions. In other planes, deviation errors in plastic turrets contributed more to the error in the boresighting of the guns than all other factors combined."

The problem is outlined in the following paragraphs with certain specific data included to convey an understanding of the order of magnitude of the effects.

Field of Vision.—The field of vision is the amount of space that the pilot can see while moving within the limit of the freedom allowed by the belt and his shoulder straps. Quantitatively, the field of vision is expressed as a percentage of the total solid angle of vision in a sphere. A good average fighter plane has a field of vision of about 70 per cent. The bubble canopy, providing as it does a clear view of the rear, contributes much to improving the field of vision.

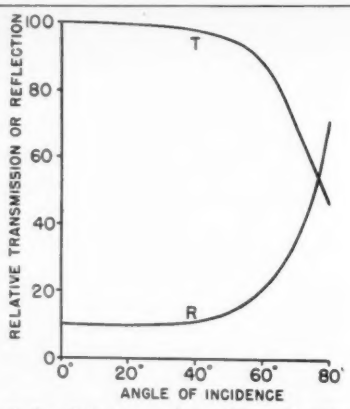


FIG. 1. Relative light transmission (T) and reflection (R) at various angles of incidence for a piece of $^1/_8$-in. plate glass laminated with 0.080-in. vinyl plastic. These factors are especially important in dim illuminations and at night. (From reference 1.)

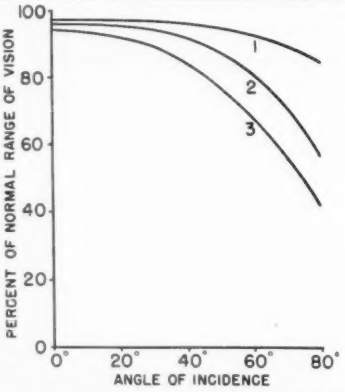


FIG. 2. Loss of range of vision through (1) plate glass, (2) clean plastic, and (3) dirty plastic windscreen at various angles of incidence. Range of vision is defined as the greatest distance at which a plane of a certain size can be seen on a clear day. (From reference 1.)

Freedom from Blind Spots.—The field of vision as determined above is not affected by narrow obstructions to the view of the pilot if he can look around them by moving his head. Obviously, however, there is an enormous advantage in keeping these blind spots to a minimum so that the pilot has full command of his field of vision with a minimum of head movement. Looking around an obstruction means that certain sections of the sky must be overlapped with greater required attention and a greater chance of failing to detect an enemy plane. Again, the one-piece canopy made an important contribution to the reduction of blind spots by eliminating the supporting structure.

Light Transmissibility.—The pilot's enclosure must transmit light as perfectly as possible. It is found that the best-known transparent material cuts down the efficiency of vision insofar as detecting a small object at a distance is concerned. Transmissibility is a function of a number of factors, including the properties of the material, the surface condition, the angle of incidence, and the surface contours.

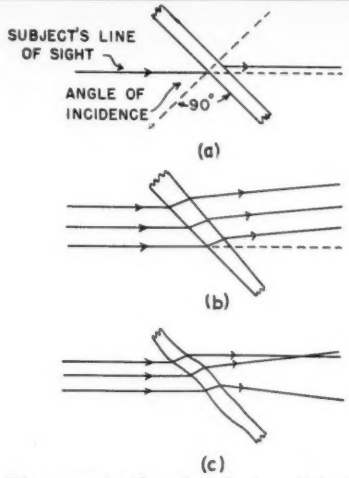


FIG. 3. Diagrams showing the effect on light beams of (a) displacement, (b) deviation, and (c) distortion. (From reference 1.)

High-grade glass appears to be the best-known material to transmit light. Plastics, such as the methyl methacrylate commonly used in canopies, can only approach the transparency of glass.

Scratches or dirt on the surface of a transparent material affect the transmission of light. Plastics are softer than glass and, of course, are scratched more easily. The importance of an enclosure that is easily cleaned cannot be overemphasized. Returned combat pilots interviewed at Wright Field stated that they instructed their ground crews to clean the canopy and windshield carefully even if they had time to do nothing else.

The effect of the angle of incidence on the relative transmission and reflection of light through glass is shown in Fig. 1. Fig. 2 shows the relative range of vision through glass and plastic, again as a function of the angle of incidence. The curves show the importance of holding the angle of incidence to a minimum, particularly with plastics.

The displacements or distortions occurring when looking through a piece of transparent material may be explained by the surface contours of the transparent material. A displacement occurs as shown in Fig. 3a when light is passing through a sheet of transparent material at a certain angle of incidence even when the two sides of the material are parallel, but the incident and emergent rays are parallel and the distortion is negligible.

When the two surfaces of the material are flat but not parallel, as in Fig. 3b, the angle of the emergent ray deviates from that of the incident ray and, as a result, the observed object as a whole suffers an apparent displacement. Such a displacement is seriously objectionable in the last stage of the combat maneuver. It does not affect the early detection of an enemy craft. Displacement should be held to a minimum in the canopy by using only sheets of uniform thickness, but a certain variation is seemingly unavoidable at the present stage in the art of plastic sheet manufacture. It should be practically eliminated, however, in all forward-view panels where only the best optical glass should be used.

When the two surfaces are not flat, as can be seen in Fig. 3c, the displacement varies from point to point. If a large object is observed through glass of this type, one part of it is displaced with respect to another part and distortion results. This is the sort of distortion that produces nausea. Spurious displacements of objects as they are viewed through different sections of the plastic can be extremely disconcerting to the pilot. At night, for instance, formation flying is made much more difficult when the light of another plane suffers such continual displacement with every slight motion of the pilot's head. This type of optical defect is produced by molding and is not found in free-formed canopies.

Domestically manufactured methyl methacrylate sheet has a thickness tolerance of eight to ten per cent. Distortion, attributable to factors other than thickness variation, has been noted. It has been reported[2] that at the end of the war the Germans had an improved process for casting methacrylate sheet, and a plant was in partial operation which produced a high percentage of sheet with a thickness tolerance inside one to two per cent. It is highly important to the optical improvement of aircraft enclosures that thickness tolerances and all other sources of distortion should be eliminated, and research should be directed to these objectives.

AERODYNAMIC PROBLEMS

Requirements for higher speeds, particularly as we penetrate the compressibility range, necessitate idealized contours for the surface of the enclosure through which the pilot demands perfect vision. In pushing up the speeds of our fighters, we find that every part of the craft must be scrutinized for contribution to a low critical Mach Number. The difference in the critical speed of molded and free-blown canopies on an experimental fighter was found to amount to $0.06M$. The better aerodynamic contours of the molded canopy were directly responsible for the difference.

As changes from paneled hatches to bubbles were made on our subcritical velocity fighters during the war, a number of aerodynamic problems were encountered which are worthy of passing note. The abrupt changes in contour, bulges, greater frontal area, and poor fuselage intersections caused some increases in drag. Elimination of the high-peaked turtledeck for clear vision aft of the bubble also affected the drag. Aerodynamic bookkeeping was a bit confused but the net result, generally speaking, was a slight or no change in high speed, and a moderate loss of performance at higher angles of attack.

Turtledeck modifications and bubble canopy installations also created a directional stability problem on at least one airplane with which we are familiar and it is probably significant that fins on other airplanes were modified more or less concurrently with the advent of

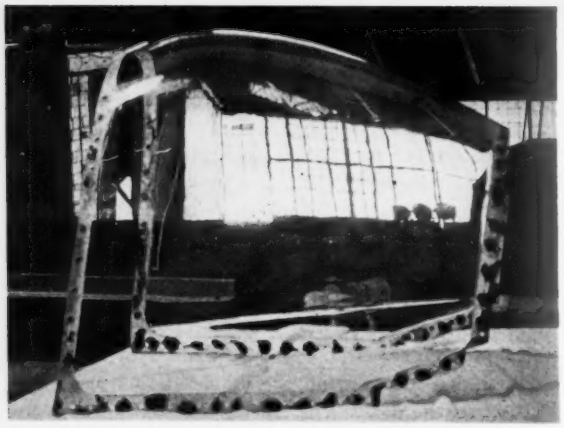


FIG. 4. Grease-formed canopy used on production fighter.

bubble canopies. These effects were most noticeable at high angles, because of the fat cheeks on the bubbles aft of the windshield, and because the poor bubble-fuselage intersection induced considerable turbulence.

The fat bubble canopy has failed in flight because of outside air loads, and pilots have experienced difficulty in opening them under certain flight conditions. The problem of air loads and pressurization bears on the required structural strength of the canopy, its supporting members, the forces required to open and close the canopy, and the design of opening, closing, and jettison mechanisms.

At first thought it may appear that the fat free-blown bubble canopy with its surface tension shape is the most ideal for pressurization. This would be the case if nothing but tension stresses were produced in the canopy. However, when the external pressure loads are added to the internal pressure loads, there is appreciable divergence from this ideal condition and the advantage of the bubble canopy is less apparent. The proper plastic-to-frame attachment can contribute much to the strength of the canopy.

FORMING METHODS

As previously mentioned, the older airplane enclosures were made up from many small, single, curved or flat panels. These curved panels were formed by merely laying the hot plastic on a suitable form, the plastic being sufficiently limber to fit the form closely. Optical distortion, ordinarily termed mark-off, was not serious on such small pieces of single curved material because the skin of the hot plastic could be chilled slightly with an air blast and partially hardened before the piece was placed on the form. This slight case hardening largely prevented mark-off. However, such chilling of the skin is poor practice because it results in locked-up stresses that make the plastic piece susceptible to early crazing.

Mold Forming

In the larger one-piece canopies, possibly best exemplified by Fig. 4, the problem of good optical properties becomes impossible when any type of contact mold is utilized. Many modifications and improvements on the mold process have been attempted and some of them have shown a fair degree of success, but, in general, it may be stated that really superior optics are not achieved when mold forming of methyl methacrylate sheet is attempted. This is readily understandable when it is considered that mold forming of any compound curved piece must of necessity draw the plastic over the mold, i.e., the plastic must slide with reference to the mold at some point on the piece. It must be remembered that ordinary methyl methacrylate sheet is polymerized (cast and solidified) between sheets of plate glass that have a fairly high degree of optical perfection. Obviously, no mold manufactured for the purpose of preparing an aircraft canopy will have an optically ground surface that is comparable to flat plate glass. Even if this were possible, the non-uniform cooling and the sliding of the hot plastic over the mold would still cause optical defects.

Some variations of mold forming have come into use which are worth mentioning. The use of grease as a separator between plastic and mold is common, and one fairly recent variation involved sucking the plastic into a female grease-coated form. Another variation in mold forming (which may or may not involve the use of grease) is known as the "snap-back" process. With this method, the canopy is blown with differential air pressure and a form is fitted into the free-blown shape. The air pressure is then released and the plastic relaxes or "snaps back" slowly and sets itself tightly over the form. It is apparent that a great deal less sliding takes place than would occur if the mold were pushed against hot flat plastic sheet but, unfortunately, some part of the plastic touches the form first and relative motion always occurs between some part of the plastic canopy and the mold. The greater the relative motion, the worse the mark-off. Good optical properties may be found in the portions of the canopy that touched the mold last and slid least; the portion that touches first and is dragged over the mold surface will be inferior.

Free Blowing

The disadvantage of inferior optics that always result from mold forming has sometimes been accepted to obtain idealized surface contours. A properly formed and fabricated free-blown enclosure does not have any mark-off and, if the original methacrylate sheet was free of defects, the final product will be optically excellent. Free blowing produces the bubble canopy. Insofar as forming is concerned, the process is exactly what its name implies. The plastic sheet is draped into a form or frame that restrains the canopy in precisely the same places and only at those places where metal structure will ultimately attach. Either positive or negative pressure may be applied to the appropriate side depending upon the design of the tool.

The primary feature in this process, and the one responsible for the optical excellence of the product, is the

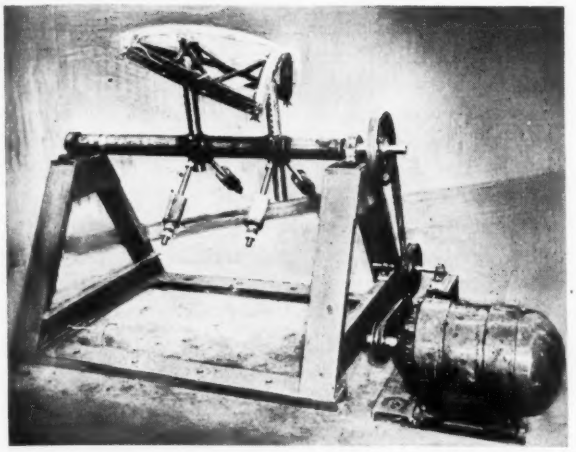


FIG. 5. Early laboratory centrifugal forming device.

forming of the hot plastic in the vision area without contact with any part of the jig; thus there can be no mark-off. In addition, mechanical forming stresses are non-existent although sometimes a fabricator locks up some stresses in the canopy by using compressed air to chill, or infrared lamps to heat, local areas, as previously mentioned. These artifices, usually directed at contour control, almost invariably produce distortion, and crazing may appear soon after the canopy goes into service.

After this brief review of contemporary fighter canopy forming methods, it should be apparent that what is needed is an improved method that will produce fairly narrow, peaked cross sections, and at the same time provide the optical excellence inherent in the free blowing method. During the past 2 years, a method meeting these specifications has been developed and it is described in the following paragraphs.

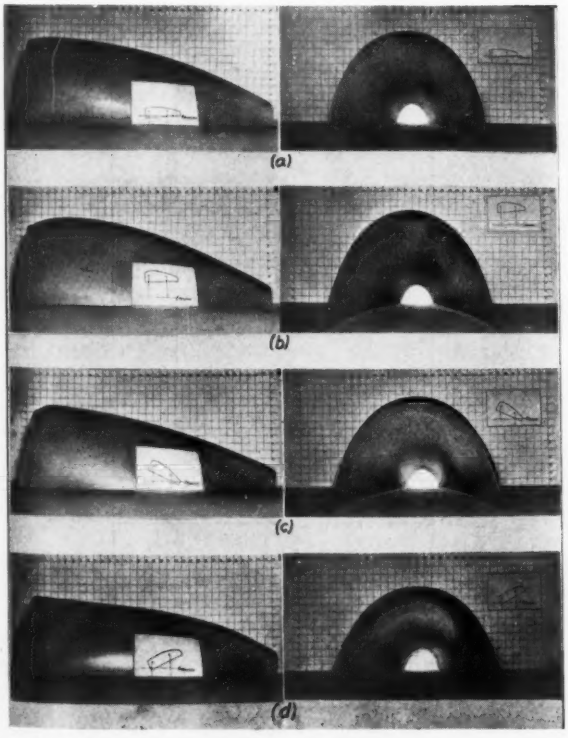


FIG. 6. Range of canopy shapes obtainable by varying the position of the canopy with respect to the axis of rotation.

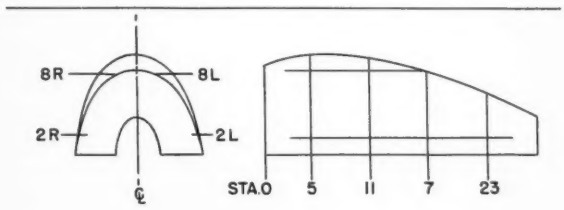
Rotoforming

This method is based on one simple idea: the use of centrifugal force instead of hydrostatic pressure as in free blowing. In common with many fundamentally simple ideas, its execution has proved to be somewhat complicated. Fig. 5 shows the original laboratory equipment used to manufacture a half-scale fighter canopy including the spinning jig and formed methacrylate canopy.

The hot plastic is attached to a frame, but just as in free blowing, there is no contact in a vision area. Contour control is achieved in a number of ways. It may be seen immediately that the forming forces and their distribution can be controlled, within limits, by varying the r.p.m. and the position of the bubble with reference to the axis of rotation.

Fig. 6 illustrates the range of canopy shapes which was obtained by merely varying the position of the canopy axis with reference to the axis of rotation as shown in the smaller sketches included.

In the photographs of Fig. 6, the canopies have been coated with opaquing material to eliminate reflections and accentuate the contours. Fig. 6c and 6d show that a large angle between the canopy base plane and the axis of rotation can result in either a flat forward or rearward end, depending upon which end of the canopy is farthest from the axis of rotation. In addition to the primary contour controls which are achieved by axis orientation and r.p.m., a surprising amount can be accom-



		Blown			Centrifugal		
		Orig. T	Formed T	% Red. T	Orig. T	Formed T	% Red. T
Station 5	2L	.132	.103	21.9	.135	.120	11.1
	8L	.136	.107	21.4	.136	.124	8.9
	℄	.140	.111	20.7	.137	.124	8.5
	8R	.140	.111	20.7	.133	.120	9.7
	2R	.137	.111	19.0	.130	.114	12.3
Station 11	2L	.132	.101	23.5	.134	.117	12.7
	8L	.139	.108	22.3	.137	.122	11.0
	℄	.141	.108	23.4	.137	.124	9.5
	8R	.141	.107	24.1	.137	.123	10.1
	2R	.138	.108	21.7	.134	.115	14.1
Station 17	2L	.132	.105	20.5	.129	.111	13.9
	℄	.138	.108	21.7	.134	.122	8.1
	2R	.133	.107	19.6	.137	.116	15.3
Station 23	2L	.130	.110	15.4	.123	.111	9.7
	℄	.135	.113	16.2	.129	.119	7.8
	2R	.133	.113	15.0	.134	.118	11.9

FIG. 7. Per cent thickness reductions found in free-blown and rotoformed canopies.

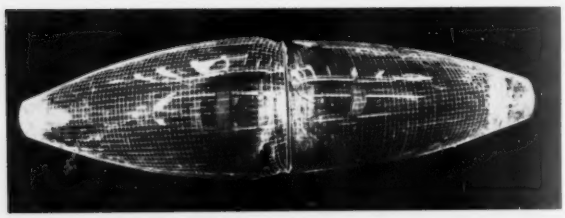


FIG. 8. Plan view of free-blown and rotoformed canopies with same base and end contours.

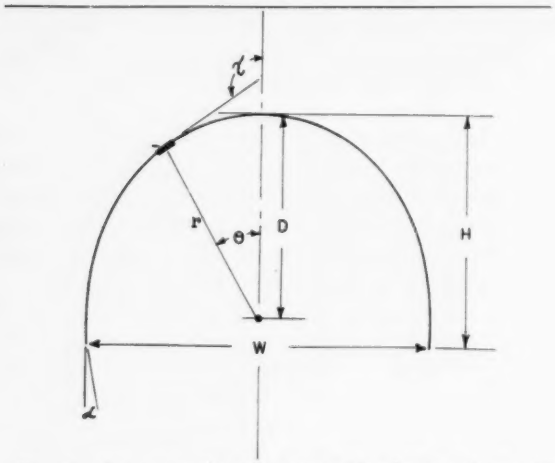


FIG. 9. A cross section of a canopy showing the three principal dimensions and the quantities used in the analytical solution.

plished through the use of drape; that is, the hot plastic can be placed in the form with some excess material in selected spots.

This also has the effect of reducing the elongation, or reductions in thickness, and is a useful technique in further controlling the contour. All canopies shown in Fig. 6 had the same flat layout, the same base contour, and the same end contours.

After examining the first rotoformed canopies, it was thought that the thickness reduction caused by forming might differ in magnitude and distribution from that found in bubble canopies. Considerable difficulty was experienced in making these comparisons because of the variations in thickness of the original plastic sheet. A rotoformed and a free-blown canopy were manufactured from carefully selected stock having minimum variation between sheets and within sheets. Both canopies had the same first dimensions; i.e., base contour, end contours, and flat layouts. The data are supplied in Fig. 7.

It can be seen from the data that the thickness reduction is appreciably less in the rotoformed canopies. This is accounted for in two ways: (1) the volume and the surface area of the rotoformed canopy are less, and less elongation is required; and (2) the original hot shape can be closer to the finished rotoformed product than to the free-blown shape.

The difference in contour of the half-size free-blown and half-size centrifugally formed canopies of the same base contour is illustrated in Fig. 8. The complete elimination of the objectionable bulge aft of the windshield section on the rotoformed canopy is apparent. The scribed lines shown on both canopies were laid out as squares on the flat sheet and some idea of the elongations can be obtained from inspection of the photographs. The data on reduction of thickness, however, provide the most satisfactory method of analyzing the draw.

The matter of shapes was also investigated analytically. For the purpose of this investigation the effect of end constraint was neglected since it was found to be negligible at comparatively short distances from the ends. With this assumption the shape of a section was found to be defined by the equation:

$$\frac{d\tau}{d\theta} = \frac{-1}{1/2 - c^2/r^2}$$

where, referring to Fig. 9,

θ = angle of the radius to an element
τ = angle of the tangent to the same element
r = radius to the element
c^2 = a constant for any particular canopy shape

This equation was solved by a step-by-step method and the results are summarized in Figs. 10 and 11.

Fig. 10a gives D/H as a function of c^2 for a particular width-height ratio of 1.5, where D is the distance from the peak to the center of rotation and H is the height of the canopy.

Fig. 10b gives the angle of departure of the canopy at its intersection with the base. This value is of particular interest in fairing the canopy into the fuselage. Finally, Fig. 11 shows a family of curves for various

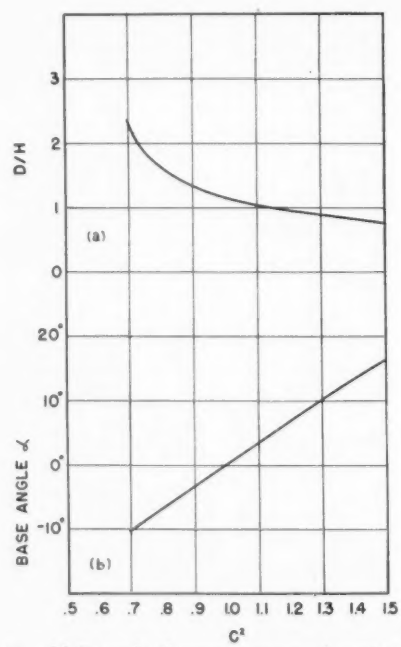


FIG. 10. (a) Per-unit distance to center of rotation, D/H and (b) base angle α, as functions of parameter c^2 for a width-height ratio of 1.5.

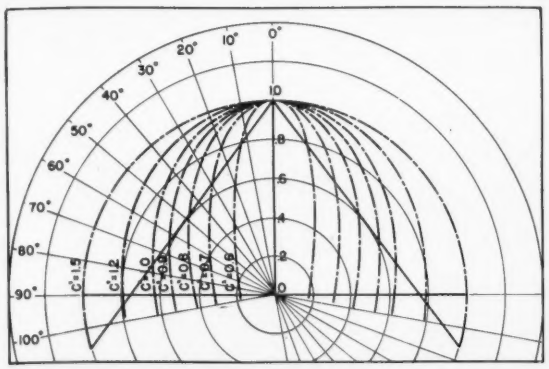


FIG. 11. Possible shapes of rotoformed canopy sections, obtained analytically.

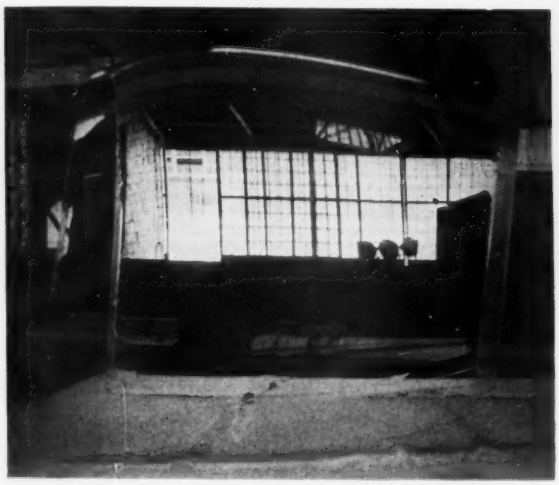


FIG. 12. Rotoformed version of canopy shown in Fig. 4.

values of the parameter c^2. The two straight lines represent a constant width-height ratio of 1.5.

A considerable amount of care is necessary to achieve optimum optical properties but the results on full-scale canopies have been excellent. The superiority of the rotoform method was illustrated in the application of the process to the F4U-4 hatch. Originally this enclosure was formed by sucking the hot plastic into a grease-covered female form. The original hatch is considered a good job of grease forming and the fabricator used a considerable amount of care in the processing, including control of temperature of the grease, mold, and plastic. Fig. 4 shows this hatch. Fig. 12 shows the rotoformed version. The absence of distortion is apparent in the latter case.

FIG. 13. Full-scale rotoformed canopies with protective coatings for installation on experimental military aircraft.

Fig. 13 illustrates four full-scale rotoformed canopies that have been fabricated during the past few months for experimental military aircraft. The photograph shows each canopy in the same perspective. The front corner of each canopy was the same distance from the camera and each canopy axis made an angle of 45° with the axis of the camera. The canopies shown in the photograph were again opaqued to eliminate reflections and permit comparison of shapes. Their optics have been uniformly excellent and fully comparable with bubble canopies made by the free-blowing process.

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Aeronautical Reviews

Aerodynamics

The views and opinions expressed in this section are exclusively those of the writers or publications named. They are in no case to be construed as those of the Aeronautical Engineering Review or the Institute of the Aeronautical Sciences.

Supersonic Wave Drag of Thin Airfoils. Allen E. Puckett. A finite body moving in a nonviscous compressible fluid, at a speed greater than the speed of sound, will experience a drag, generally called "wave" drag. This drag may be computed in special cases by assuming that the disturbance velocities produced by the body are small compared to the velocity of the body. With this assumption of small perturbations, the equations of motion for the fluid may be linearized and solved fairly easily. This was done by Ackeret for two-dimensional thin airfoils (i.e., infinite span). For slender symmetric bodies, the solution was given by von Kármán and Moore. At the suggestion of von Kármán, the methods have been extended to the case of a three-dimensional body that is extremely thin in one dimension, such as an airfoil.

Using the linearized equation for compressible fluid motion, solutions to the flow around any thin symmetric body at zero lift can be found. As an example, the drag of a simple triangular or "delta" wing with a double-wedge profile has been computed. It is found that the drag coefficient of such an airfoil may be reduced to values much below that of a two-dimensional airfoil, but that this reduction will depend upon proper sweepback angle and location of maximum thickness point. *Journal of the Aeronautical Sciences*, September, 1946, pages 475–484, 14 illus.

Compressibility Effects Data. C. W. Terry. As a result of test work accomplished by aerodynamicists, calculations have been made to show that with the reduction of drag and the increase of power, supersonic speeds in normal flight will soon be possible. Without going into the power aspects of the problem, an attempt is made in this paper to determine whether or not such speeds are attainable with present aircraft design.

The basis of the study is a comparison of lift coefficient available from an airfoil, as shown by high-speed flight-test results, with lift coefficient required for normal flight as calculated from simple aerodynamic equations. Four graphs aid in explaining the text. The conception of coefficient of lift required for flight and coefficient of lift available for a given airplane is represented by the first curve. Flight-test results show that maximum coefficient of lift decreases with increased speed for any airfoil; this is shown in the second graph. Typical curves of coefficient of lift required and maximum coefficient of lift available, extended to the high-speed range, are presented in the third set of curves. Mach Number 1.0, at a higher altitude, corresponds to a lower true air speed at lower altitudes. Therefore, this limitation would affect the high-speed flight problem to a marked degree. The other major factor is that the limiting value of the Mach Number is less than 1.0. The fourth graph develops corresponding Mach Numbers and coefficients of lift for specified altitudes. *Aero Digest*, August, 1946, pages 76, 77, 107, 108, 4 illus.

Shock Waves in Compressible Flow. D. M. Davies. It is noted that earlier classical treatises on aerodynamics, which were concerned with the properties of incompressible fluids, gave an excellent theoretic background to the aeronautical engineer. With the steady increase of aircraft speed, however, it soon became evident that the theory would have to be extended to take compressibility into account.

One important result, brought out by Glauert's analysis, was the modification of the flow pattern with increasing Mach Number. A more striking divergence of compressible from incompressible flow, first encountered at near sonic speeds, is the occurrence of shock waves. A considerable amount of attention is now focused on the repercussions of shock waves on airplane design. An outline of the phenomena occurring in the trans-

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sonic speed range is presented. *Aircraft Engineering*, August, 1946, pages 261–263, 9 illus.

Augmented Flow. The method of augmenting fluid flow, called the Coanda effect, devised by the Rumanian inventor Henri Coanda, is described as the phenomenon which occurs when a fluid stream is ejected at high speed from a slot, one wall of which is developed into one-half of a divergent passage. The writer states that the stream is deflected from the axis of flow and follows the slope of the divergent wall while increasing in velocity and in mass by entraining additional air. It is claimed that, with proper design of the divergent steps, it is possible to change the direction of a fluid stream through 180° with the outer side of the passage open. Recent studies, directed toward augmenting flow through nozzles for air cooling and in order to provide useful thrust, as well as rotary pumps for gases and liquids, are examined. *Flight*, August 15, 1946, pages 174, 175, 6 illus.

Coanda Effect. Frank Lawton. Reference is made to the many "unorthodox" theories that have been put forth in the field of fluid mechanics, particularly as applied to jet propulsion and rocketry. One such "controversial" theory is the Coanda effect which is explained in this article. It comprises a statement regarding the behavior attending the emission at high velocity of a compressible or incompressible fluid from an orifice fitted with one-half of a divergent trough. Some possible applications of the idea are considered. *American Helicopter*, August, 1946, pages 31, 41, 4 illus.

1,000 Miles an Hour. James L. H. Peck. The data obtained from the release of an 8-ft. experimental bomb from 40,000 ft. by the N.A.C.A.'s Compressibility Division at Langley Field, Va., introduce the subject of sonic and supersonic speed missiles and the aerodynamic factors necessitating changes in design. The measurement system based on Mach Numbers is explained in nontechnical language in conjunction with compressibility effects at different altitudes and temperatures. Examples are supplied of specific compressibility effects under given conditions, and the corresponding aerodynamic design necessary to avoid shock waves is discussed. Structural as well as aerodynamic design factors are studied with reference to the effects of the friction heat encountered at high speeds. The writer predicts that the controls of supersonic craft will probably take the form of small spoiler plates instead of the hinged surfaces of large area now used for guidance, pitch, and bank. *Air Trails*, September, 1946, pages 24–27, 70, 72, 7 illus.

Airfoil Development and Structure Within the Cambered Surface. Part X. Roy A. Liming. Typical problems to which analytic calculation techniques can be applied are solved in the tenth section of a serial article. Eight typical problems of this type are outlined as follows, together with the standard analytic calculation procedures used in solving them: (1) True length of a line segment. A typical application is the calculation of the true distance along the hinge centerline from the inboard end of the aileron to each of three hinge points. (2) True angle between two lines. A familiar problem involving this relationship consists of finding the angle between the upper mold line of the aileron main spar and the trace of a normal aileron-rib station on the upper spar-cap plane. (3) True angle between a line and a plane. This is exemplified by the determination of the true angle between a normal aileron rib-station plane and the lower mold line of the aileron main spar, in order to design an attachment fitting at the inboard side of the outboard aileron rib. (4) True angle between two planes. This technique has many applications, an example being the design of a fitting attaching an aileron-hinge bracket to the wing rear spar, making it necessary to determine the true angle between the plane of the hinge bracket and the plane of the rear spar. (5) Distance from a point to a plane. An example is the equation of the plane of the rear face of a wing rear spar and the coordinates of the

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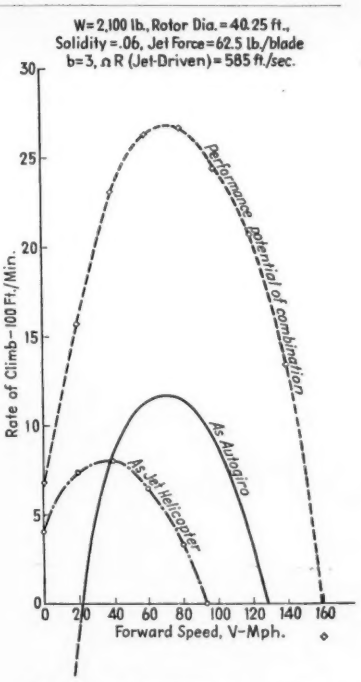
center point of a flap-hinge fitting, it being necessary to determine the distance from the center point to the spar plane. (6) Angle made on one plane by the intersections (traces) of two other planes. One of the most effective applications is in the design of a fitting for attaching an aileron-hinge bracket to a wing rear spar, it being necessary to find the angle between the trace of an aileron normal rib-station plane on the spar and the trace of the wing-reference plane on the spar. (7) Distance from a point to a line in space. This is exemplified by a problem in which it is required to find the distance from an aileron-hinge point, with given coordinates, to the upper mold line of a wing spar passing through a given point. (8) True distance between two skew lines in space. A common application of this technique is to the problem of determining clearances between control cables.

For each of the foregoing problems the numerical solution is given, together with the pertinent formulas developed in earlier installments of the article, showing how numerical values are substituted in the various equations so that exact mathematical solutions can be reached. *Aero Digest*, August, 1946, pages 72–75, 111, 115, 8 illus.

General Tank Tests of a $^1/_{10}$-Size Model of the Hull of the Boeing XPBB-1 Flying Boat—Langley Tank Model 175. Douglas A. King and Mary B. Hill. General tank tests of a $^1/_{10}$-size model of the hull of the Boeing XPBB-1 flying boat were made in the Langley tank No. 1. Tests were made of the forebody alone, the forebody with afterbody, and the forebody with afterbody and tail extension, which represented the complete hull.

In addition to the usual measurements of resistance and trimming moment, measurements were made of the length of the planing bottom which was wetted by the water. The draft of the forebody alone was measured by a method that eliminated errors caused by up-and-down surges of the water in the tank. The application of the data to the determination of stability derivatives, frictional resistance, and the computation of the forces on the constituent parts of the hull is discussed briefly. *National Advisory Committee for Aeronautics, T.N. No. 1057*, July, 1946.

Effects of Tip Dihedral on Lateral Stability and Control Characteristics as Determined by Tests of a Dynamic Model in the Langley Free-Flight Tunnel. Herman O. Ankenbruck. The effects of tip dihedral on lateral stability and control characteristics were investigated by flight tests of models in the Langley free-flight tunnel. The geometric dihedral angle was varied over a wide range with the dihedral breaks at the wing root and at 50 to 75 per cent of the semispan outboard of the wing root. The vertical-tail area was varied from 5 to 15 per cent of the wing area. The model was flown with various combinations of these variables at lift coefficients from 0.4 to 1.0.



Sea-level performance of autogiro jet-assisted take-off. (See "Practical Engineering of Rotary Wing Aircraft," page 63.)

At low lift coefficients and at similar values of effective dihedral and directional stability, no differences were noted in the flying characteristics with full-span or tip dihedral. At high lift coefficients, however, large angles of tip dihedral caused lightly damped lateral oscillations (predominantly rolling), which were considered objectionable and possibly dangerous. This abnormal lateral oscillation was believed to be caused by a reduction of the damping in roll due to early stalling at the dihedral juncture. *National Advisory Committee for Aeronautics, T.N. No. 1059*, July, 1946.

Flight Tests of Experimental Beveled-Trailing-Edge Frise Ailerons on a Fighter Airplane. R. Fabian Goranson. Flight measurements have been made to determine the characteristics of a pair of experimental ailerons designed to provide a close degree of balance and to maintain a linear variation of aileron effectiveness with aileron angle through a large deflection range. The ailerons, which were tested on a production fighter airplane, incorporated an upswept Frise nose and a beveled trailing edge. These ailerons were designed for application to an experimental fighter airplane, which was to employ wings similar to those of the test airplane as outer panels added to a rectangular center section. Individual aileron hinge moments, aileron rolling effectiveness, and stick-force characteristics were measured in abrupt aileron rolls over an equivalent airspeed range from approximately 109 to 276 m.p.h.

The results of the tests indicated that the variation of rolling moment with aileron deflection was linear for a deflection range from $-24.5°$ to $22°$. A deflection range of $\pm 24°$ would give a value of 0.137 for the helix angle described by the wing tip during roll for the test airplane, or 0.098 for the experimental fighter airplane. With a rigid control system, a range of aileron deflection of $\pm 24°$ could be reached with a 32-lb. stick force at 202 m.p.h. Data are presented showing the critical importance of the effects of control-system elasticity in determining the stick forces. The calculations indicated that overbalance encountered on the test airplane was the result of control-system stretch and that, with the control system of the experimental fighter airplane, the aileron stick forces would be unsatisfactory at a speed of 300 m.p.h. or more. The data presented also show that exceptional care must be exercised in the construction of closely balanced Frise ailerons because small protuberances on the leading edge of the balance may cause overbalance or premature stalling of the balance on the up-deflected aileron. Calculations were also made to show the increase in aileron effectiveness available if the aileron span were extended. *National Advisory Committee for Aeronautics, T.N. No. 1085*, July, 1946.

Note on Momentum Methods of Measuring Profile Drags at High Speeds. A. D. Young. The theory and application of two momentum methods of measuring profile drag at high speeds are developed. The first method is an extension of Jones' method; the second method is based on the solution of the momentum equation of the wake. The first method is considerably easier to apply than the second but the theory upon which it is based is less satisfactory. Application to the results of some tests made in the National Physical Laboratory high-speed tunnel shows, however, that the results given by these two methods are in close agreement. It is concluded that the first method is reliable and is preferable on account of its greater simplicity.

It is shown that, for tests at speeds below the appearance of extensive shock waves and for which the Mach Number equals 0.7, it is sufficiently accurate to use Jones' incompressible-flow formula and then to apply the compressibility correction given in "Note on the Effect of Compressibility on Jones' Momentum Method of Measuring Profile Drag," *R. & M. No. 1881*, February, 1939. *Ministry of Aircraft Production, Aeronautical Research Committee R. & M. No. 1963*. British Information Services, New York, $0.75.

The Virtual Inertias of a Tapered Wing in Still Air. W. Prichard Jones. The inertial constants of a wing are usually determined by resonance experiments in still air. As the

The Navy's NEW Seahawk

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Drawing on the wartime Seahawk's extensive service with the Pacific fleet, Navy and Curtiss-Wright engineers have developed the SC-2, a new scout plane of unprecedented range, speed, firepower, and general utility.

More room in the fuselage, with an extra seat aft of the pilot, provides for air-sea rescue work or for reconnaissance photography. Firepower has been increased beyond that of previous types by the installation of rockets under the wing. The new, hydraulically operated cabin enclosure is equipped for quick opening by compressed air in emergencies. A Wright Cyclone engine with two-speed supercharger gives the SC-2 a service ceiling of 28,000 feet, and provides increased range and speed. It is equipped with a Curtiss Electric hollow steel blade propeller.

The Seahawk is now being delivered to the Navy from the Curtiss-Wright, Columbus, Ohio, plant.

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values obtained include the virtual inertia or aerodynamic inertia effect due to the external air, they should not be used to predict critical speeds for flutter in conjunction with theoretically deduced derivatives, such as those given in "Flexure-Torsion Flutter Derivatives for Semi-Rigid Wings," *R. & M. No. 1942*. The allowances for the virtual inertia effect can be estimated by the methods explained in this note. Formulas obtained by two-dimensional strip theory are given, by means of which the virtual inertias of the model tapered wing used in *R. & M. No. 1945* titled "Derivative Measurements and Flutter Tests on a Model Tapered Wing" can be calculated.

Identical results are deduced by three methods that depend respectively on (a) vortex sheet theory, (b) doublet distribution, and (c) potential flow. It is thought that method (b) could be developed to determine the inertial coefficients of a wing of finite span directly without resort to two-dimensional strip theory. *British Ministry of Aircraft Production, Aeronautical Research Committee R. & M. No. 1946*. British Information Services, New York, $0.40.

The Experimental Determination of the Interference on a Large Chord Symmetrical Joukowski Aerofoil Spanning a Closed Tunnel. J. H. Preston and N. E. Sweeting. The interference on a 20-in. chord simple Joukowski airfoil approximately 12 per cent thick has been measured in the 4-ft. No. 2 tunnel at the National Physical Laboratory. Tunnel constraint was removed by shaping the walls over a limited distance fore and aft of the model to the calculated streamlines of the unbounded flow about the wing. When the model chord is less than half of the tunnel height and the incidence is less than 9°, the wing can be replaced by its equivalent doublet at the position of maximum thickness, together with a vortex with the same circulation at the center of pressure, for the purpose of calculating the streamlines.

The measured interference on the forces and moments, expressed as a percentage, agrees closely with that predicted by potential flow theory for a flat plate. In particular, tunnel constraint increases the lift by some 7 per cent; the moment about the leading edge by some 10 per cent; moves the center of pressure forward 0.8 per cent of chord; and increases the hinge moment/incidence slope by some 15 per cent. The values of the lift coefficient, moment coefficient, center of pressure, and hinge moment coefficient with no tunnel constraint are fairly close to the theoretic values. As might be expected, therefore, the measured scale effect on lift was found to be small, and so were the effects of turbulence wires. *British Ministry of Aircraft Production, Aeronautical Research Committee R. & M. No. 1997*. British Information Services, New York, $1.05.

The irregularity of receipt of publications from abroad necessitates the review of articles in issues several months late. This is done to provide readers with information regarding foreign technical progress as soon as the issues are available in the United States.

Air Laws and Regulations

Designated Engineering Representatives. The purpose of this Safety Regulation Release is to establish a system that has been developed in an effort to expedite the approval of engineering work, exclusive of flight testing and analyses, leading to type certification of an aircraft. Under this system an aircraft manufacturer's employees can be designated as engineering representatives of the C.A.A. and authorized to provide engineering data for the Administration with the object of reducing the time required to obtain a type certificate.

The conditions are outlined under which a manufacturer engaged in the design of civil aircraft may nominate individuals in his employ for appointment as engineering representatives. There are three classifications: structural engineering representative, power-plant engineering representative, and miscellaneous design engineering representative. The qualifications for such representatives are outlined, as well as the authority and responsibilities of the manufacturer's designee. *C.A.A. Safety Regulation Release No. 212*, July, 1946.

Proposed Safety Regulation Release on Approval of Aircraft Components and Materials. The purpose of the proposed release is to outline the procedure in cases where applications are received for the separate approval of aircraft components and materials, independently of their installation in a particular aircraft. It is also the intention of the release to clarify the status of existing Government and industry standards and specifications with regard to the approval by the C.A.A. The products involved range from the small items, such as pulleys, control cable fittings and bearings, to parts or assemblies manufactured as a unit, such as tailwheel assemblies, electrical and hydraulic system parts, power-plant accessories, cockpit enclosures, and certain primary structural assemblies.

The proposed release gives details concerning approval classifications, procedure with regard to products, and the use of type-certificated and acceptable products. Appendix A gives a list of items that will be type-certificated. Appendix B lists items that will be specified on C.A.A. "Acceptable Products Listings" and approved in accordance with the general procedure outlined. This list includes airplane equipment, power-plant equipment, electrical and radio apparatus, and instruments. Appendix C gives a list of typical products that will be approved only as part of a type-certificated article. Sample listings for blind-type rivets and turnbuckles are shown. *C.A.A. Safety Regulation Release No. 213*, July, 1946.

Air Transport, General

Air Transport and the Public. Viscount Knollys. The Chairman of British Overseas Airways Corporation expresses some thoughts on the fundamentals of air transport. He undertakes to supply answers to the questions concerning what the public is going to need and why, and where and how the air-transport industry is going to provide it. The writer presents the problem, discusses the results of a study of the factors, gives available information about new developments, and describes some of the difficulties that must be faced. Consideration is given to the demand for air transport, the equipment required, and the type of service which must be provided. *The Journal of the Institute of Transport*, June-July, 1946, pages 271–283, 2 illus.

Air Transport, Cargo

Cargo Handling Facilities. John H. Frederick. Requirements are listed for proper handling of air freight, as a solution to the problem caused by the existing inadequate facilities for efficient loading and unloading. Among the improvements suggested are powered conveyers, cart trains, and lift trucks. The writer also recommends separate airports for passengers and air freight. *Southern Flight*, August, 1946, pages 49, 51, 1 illus.

Air Transport, Scheduled

How Big? Frank Howe. A number of air-line officials express their opinions on the feasibility of increased size in transport aircraft. The consensus maintains that the Douglas DC-6, Lockheed Constellation, Boeing C-97, and others of this immediately forthcoming type will suffice for many years to come. Among the reasons given for this view are that smaller aircraft carrying fewer passengers can offer more flexible service than one large aircraft, and the cost of operation is expected to be lower. However, large airplanes are favored for long ocean flights. *Skyways*, September, 1946, pages 36, 37, 82, 84, 3 illus.

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Airplane Descriptions

The Northrop XB-35 Flying Wing Superbomber. John K. Northrop. The President of Northrop Aircraft, Inc., discusses the XB-35 flying wing, which, it is noted, is the result of an effort to produce a heavy Army bomber of superior performance. The meaning of the term "flying wing" is defined. It is pointed out that a "pure" wing has never yet been built inasmuch as there have always been unavoidable protuberances, such as propeller-shaft housings, gun turrets, etc., but that the XB-35 does approach the all-wing ideal in that it has no fuselage or external control surfaces other than those incorporated in the wing itself. Reference is made to stability and control difficulties experienced with wing-type aircraft which had to be overcome. It is stated that a review of experience with wing types shows that the XB-35 is not of itself a radical design but is rather a normal development of the step-by-step program carried on for almost 25 years. Details of this program are set forth and design features of the XB-35 are discussed. *Aviation*, August, 1946, pages 55–61, 12 illus.

Record Technicalities. Details are given about the modifications of the Gloster Meteor IV and the preparation of the aircraft for attempts to establish new world speed records. The changes made in the air frame and the work performed on the Rolls-Royce Derwent gas-turbine engines are reviewed, together with comments concerning the method of conducting and timing the speed tests. *Flight*, August 15, 1946, pages 166, 167, 2 illus.; "The Two Record Machines," *The Aeroplane*, August 2, 1946, page 119.

Chrislea Ace. The postwar Chrislea Ace, four-seater, high-wing light plane is pictured and described briefly. Fitted with a fixed tricycle landing gear, the fuselage is of fabric-covered welded steel tubing. Production models will, however, have metal wings and tail units. All three control surfaces are operated from a single wheel control. Lateral movement of this wheel from a fulcrum point at the instrument panel operates the rudder; an up-and-down movement from that point controls the elevators; and the rotation of the wheel itself operates the ailerons. The arrangement is intended not only to simplify control, but also to leave the floor space unobstructed. The prototype is fitted with a foot-operated accelerator in addition to the normal throttle control, and the brakes are applied through a "dual" pedal. The estimated performance includes a maximum speed of more than 120 m.p.h., a cruising speed of 110–120 m.p.h., and a range of 390 miles. The overall weight will be 1,650 lbs. *Flight*, August 15, 1946, page 172, 4 illus.

The Bréguet 730 Flying-Boat. The general characteristics, weights and performance, and diagrams of the Bréguet 730 and 731 are included in a brief description of these flying boats. It is stated that the four-engined Bréguet 731 is a peacetime version of the Bréguet 730. The main difference between the two versions is that the Gnome-Rhone 14 N 44 and 45 engines of the 730 have been replaced by Gnome-Rhone 14 R in the 731, giving the latter 1,479 hp. at take-off and an increase from 7.87 to 14.76 long tons in useful load. The construction of the two planes is the same, both being cantilever monoplanes. The engines are mounted in the leading edges of the wings, which are of the box-spar type. The construction throughout is metal with the exception of the movable surfaces, which are fabric covered. The engines are accessible in flight through the inside of the wings. General specifications of both airplanes are tabulated. *Aeronautics*, August, 1946, page 47, 1 illus.

Commonwealth Aircraft. W. Green. An outline of the design, production, and operation of various aircraft built by the Commonwealth Aircraft Corporation of Fisherman's Bend, Melbourne, Australia, includes descriptions of the Wackett Trainer, the Boomerang fighter, the Woomera general-purpose monoplane, and the Australian-built Mustang fighter. In addition to particulars regarding the construction, power plants, armament, and other features of those airplanes, the article reviews some of their accomplishments in the service of the Royal Australian Air Force in the late war. *Flight*, August 15, 1946, pages 164a–165, 6 illus.

British Ultra-Light Aeroplanes—1918–1946. A. J. Jackson. A history, from 1918 to date, of British light planes of 45 hp. or less, is accompanied by photographs and a table of detailed specification data. *The Aeroplane Spotter*, July 27, 1946, pages 174–176, 20 illus.

Roadable Flying Jeep. A. W. Shaw. The Stinson L-13, successor to the L-5 "Flying Jeep," features folding wings to facilitate ground handling and highway transport. Consisting of left and right sections of all-metal construction, the wing utilizes two spars of conventional tension field web and extruded flange construction. Leading and trailing edges, which are parallel at the base, taper sharply toward the tip from points located approximately in the center of the span of each section. Wing sections attach to the upper fuselage longerons at two points and are braced on each side of the fuselage by single struts. Composed of two sections fastened together by four bolts, the fuselage has a forward or cabin section of welded tubular steel construction, covered by aluminum-alloy skin, and an aft section of aluminum semi-monocoque construction. Three jettisonable doors are provided in the cabin. The airplane is powered by one 245-hp. geared Franklin engine, Model XO-425-5, of the air-cooled, horizontally opposed type. The total fuel capacity is 60 gal. in two tanks. The L-13 has dual side-by-side controls, with the right-hand controls removable. A simple control lock secures all surfaces in neutral position. On the main landing gear, wheels and brakes are mounted on an axle that includes a vertical spindle for attachment to the main strut. *Southern Flight*, August, 1946, pages 29, 65, 2 illus.

Coupled Twin. A description of the French M.A.T.R.A.-designed R-75, powered by twin Mathis, 175-hp., air-cooled GR-7 engines, driving a single propeller, is accompanied by a designer's sketch and plan and profile diagrams. The engines are mounted in the wings in the normal way, with extensions from the supports forming a twin-boom tail structure. Through a system of shafts, a bevel box, and a free-wheeling arrangement, the two engines drive a single pusher propeller aft of the central nacelle. According to calculations, the maximum speed at sea level with both engines in action is 218 m.p.h. and 155 m.p.h. with one engine throttled back. The respective rates of climb at sea level are 1,214 ft. per min. against 345 ft. per min., while the ceilings are 18,000 ft. and 7,500 ft. The tail plane is designed with a high aspect ratio so that the two elevator surfaces can at the same time perform the duties of ailerons. These elevator-ailerons are normally operated through a fairly conventional control system but can be locked, leaving a two-control arrangement. *Flight*, August 1, 1946, page 107, 2 illus.

First Supersonic Airplane, XS-1. The first pilot-carrying airplane designed to travel faster than sound has been built for the National Advisory Committee for Aeronautics as a research tool to probe the realm of supersonic flight. The craft, designated the XS-1, has been constructed by Bell Aircraft Corporation under contract with the Army Air Forces, and is based on high-speed design information provided by the N.A.C.A., according to specifications worked out among the N.A.C.A., the A.A.F., and the Bell company. The airplane has already been flown in unpowered glide tests and is to make its first rocket-powered flights during the fall of 1946. The project is part of an intensive high-speed research program being carried out by the N.A.C.A. in close cooperation with the armed services. A similar project is in progress under a Navy contract with Douglas Aircraft Company, Inc.

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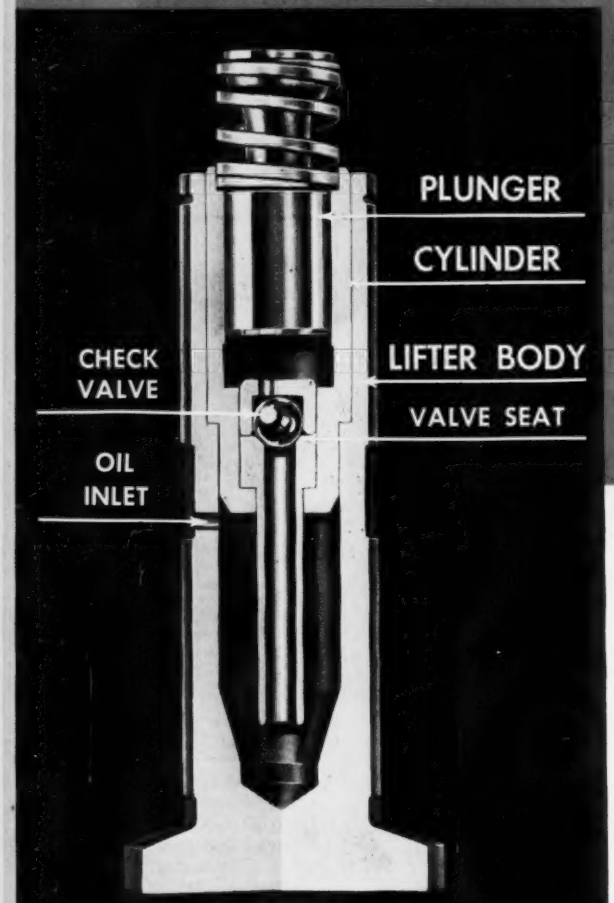

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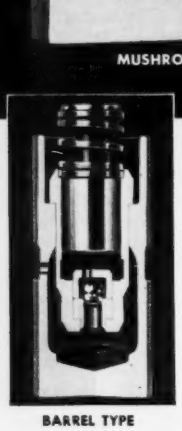

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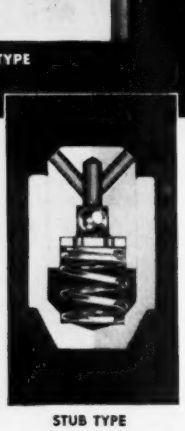

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The *Zero-Lash* Hydraulic Valve Lifter is a simple, positive-action device which automatically adjusts its own length during each revolution of the camshaft, to compensate for expansion or contraction in the valve train. Here's how it works:

The hydraulic unit consists of a plunger operating in a cylinder. The plunger is held in its outermost position against the push rod, or valve stem, by a light spring. The chamber below the plunger is kept filled with oil by pressure from the engine lubricating system. When the check valve is closed, the column of oil in the chamber being noncompressible, lifts the push rod or valve stem as positively as if the lifter were a solid unit.

Accurately determined clearance is provided between the plunger and cylinder wall permitting the escape of a small amount of oil from the chamber. This leakage automatically compensates for expansion in the valve train allowing for positive valve seating.

On the other hand, when the valve train *contracts*, the spring holds the plunger in its outermost position. This relieves pressure in the chamber, opening the check valve and permitting the intake of oil from the lubricating system. Thus the lifter corrects its own length each time the valve closes, to maintain zero clearance.

Zero-Lash Hydraulic Valve Lifters are available in three basic types (mushroom, barrel, and stub) for all types of internal combustion engines—gasoline and Diesel.

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Eaton Engineers will be glad to discuss the application of Zero-Lash Hydraulic Valve Lifters to engines now in design.

Illustrated literature covering the design and operation of Zero-Lash Hydraulic Valve Lifters, including reports of outstanding service records, will be furnished upon request.

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The Bell XS-1 is completely instrumented by N.A.C.A. research engineers to obtain new and unknown facts on flight through and above the speed of sound. The original contract provides for the airplane to be built for the A.A.F. acting in its capacity of specifying and procuring agent. The airplane is to be acceptance-tested by the manufacturer to meet certain specifications of performance and handling up to a speed limit of 80 per cent of the speed of sound, or about 612 m.p.h. at standard sea-level temperature. At this point the XS-1 is to be turned over to the N.A.C.A. for flight research up to 120 per cent of the speed of sound, or beyond if possible. When the airplane has been flown up to its safe upper limit of speed and the desired records have been gathered, the XS-1 will be turned over to the A.A.F. for further experiment. The knowledge gained is expected to be incorporated in subsequent designs to carry on the quest for still higher speeds. The original contract specified a climb to 35,000 ft., with level flight carried on from there. Plans by Bell Aircraft Corporation and the A.A.F. indicate that the XS-1 may be taken up to 35,000 ft. by a B-29 and released to attain still higher altitudes to achieve greater speed.

The XS-1 is the result of high-speed research carried on by the N.A.C.A. since 1939 and incorporates the latest supersonic knowledge. All studies on models of the XS-1 were conducted in the N.A.C.A.'s wind tunnels from the early stability tests in the 7- by 10-ft. tunnels and the spin tunnel, to the later transsonic investigation in the 8-ft. High-Speed Tunnel. Drag and thrust information through the upper transsonic range was furnished chiefly by studies of free-falling test bodies released from high altitudes. These streamlined "bombs" exceed the speed of sound and have furnished the most accurate information on the increase of drag at sonic speed and the thrust required to overcome it. The research program on the XS-1 will be devoted to study of the control and handling qualities of the airplane around the speed of sound, drag and performance information, air pressure distributions over the wings and tail, and measurements of the forces encountered which will be important to proper design of structures for new high-speed aircraft. *National Advisory Committee for Aeronautics.*

Curtiss-Wright Corporation's new XBT2C experimental bomber-torpedo plane.

Boeing Stratofreighter Double-Deck Cargo Plane. The Boeing Stratofreighter is a new double-deck, four-engined, all-cargo airplane designed to operate at a direct cost of 3.9 cents per ton-mile. It has a usable volume of 6,140 cu.ft. and will carry a maximum pay load of 41,000 lbs. at speeds of 300 and 350 m.p.h. It is powered by four 3,500-hp. Pratt & Whitney Wasp Major engines, equipped with four-bladed Curtiss electric reversible-pitch, full-feathering propellers. General Electric BH-4 superchargers are included in the power plant, reported to be the first such installation on a commercial cargo airplane.

Among the features are four cargo compartments, each separately accessible for maximum versatility, and each with provision for rapid, economical loading. Short-haul cargo may be conveniently loaded or removed from the three lower deck holds at truck-bed level without disturbing the main deck load in the fourth and largest compartment. The upper deck is 74½ ft. long, nearly twice the length of an average railroad boxcar. The main compartment is loaded by means of an electrically powered hoist and crane through a pair of "clam-shell" doors located at the aft end of the airplane on the under side of the inverted "figure-eight" fuselage. Nearly 13 ft. in length, the doors are 8 ft. 8 in. wide at the forward end and measure 5 ft. 11 in. wide at the aft end. These doors, with the spaciousness of the upper-deck compartment, permit the loading of large-dimension cargo such as packages 6 ft. high, 6 ft. wide, and 15 ft. long. The upper deck will accommodate four such boxes.

The Boeing-designed altitude-conditioning system, which maintains sea-level conditions at all altitudes up to 15,000-ft. and 6,000-ft. conditions at 25,000 ft., has been included. Advanced refrigeration and heating systems also are planned, thermostatically controlled to provide special temperatures in each of the four compartments if desired. Designed to function on the ground as well as in the air, the heating system will maintain 60°F. within the airplane despite outside temperatures as low as −67°F., while the refrigeration system may be set to keep the cabin at 45° even though temperatures outside range as high as 100°. If scheduled to carry a mixed load of flowers, vegetables, sea foods, and live commodities on a given flight, it would be possible in the Stratofreighter to separate the cargo, maintaining cabin conditions best suited to the product being carried in each compartment. *Boeing Aircraft Company.*

Curtiss-Wright SC-2 Seahawk. Delivery to the U.S. Navy of a new model of the Curtiss-Wright SC-2 Seahawk scout plane has been started. Improved performance and wider utility for scouting and air-sea rescue operations feature the new plane, which will be placed in service aboard the battleships and ships of the cruiser class, supplementing the SC-1 version of the same type.

A Wright Cyclone engine with a two-speed supercharger and offering a substantial weight-saving as well as increased accessibility for easier maintenance has been installed in the new model. Capable of flying at speeds greater than 250 m.p.h., and with a range in excess of 650 miles, the SC-2 has a service ceiling of 28,000 ft. It is a low-wing monoplane with a gross weight of 7,800 lbs., wing span of 41 ft., and an overall length of 36 ft., and is normally operated as a seaplane with Edo floats.

A permanent seat located inside the fuselage back of the cockpit is one of the improvements for rescue work which have been installed. Also, reconnaissance photography with a K25 Fairchild aerial camera will be possible. A new-type cabin enclosure, hydraulically operated, capable of being opened in emergencies by compressed air, is an added feature. The cockpit has instrument and control panels of a new design. The fire power has been increased by the installation of rockets on the wings. *Curtiss-Wright Corporation, Airplane Division.*

The Curtiss-Wright XBT2C-1 experimental bomber-torpedo airplane built for the U.S. Navy combines high performance with flexibility of usage in combat service. A large, fully enclosed bomb bay is designed to accommodate either a full-sized aerial

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torpedo, a variety of heavy bomb combinations, or a large aerial rocket. Provisions are incorporated also for carrying bombs and rockets externally on the wings. Two 20-mm. fixed cannons are mounted in the wing. Basically a single-place airplane, the XBT2C can also carry an auxiliary crewman in a special "jump" seat. The extra seat arrangement is located within the fuselage aft and below the pilot, and is used on special radar scout missions. Power is supplied by a Wright R5350 engine with two-speed supercharger, developing more than 2,500 hp. It is equipped with an engine-cooling fan for high-altitude operation and a greater rate of climb. Loaded with a torpedo, the XBT2C weighs more than 18,000 lbs., has a range of over 1,400 miles, and flies at a speed considerably greater than wartime carrier-based bombers. *Curtiss-Wright Corporation, Airplane Division.*

Edo XOSE-1 Scout Observation Seaplane. Limited specifications on a new Navy scout observation plane for catapult use from battleships and cruisers have been released, with Navy permission, by Edo Aircraft Corporation. The new single-engined craft is known as the XOSE-1. The XOSE-2, a modified version of the plane, also has been announced. Although the manufacturer has supplied virtually all the flotation gear for naval seaplanes since before the war, this is the first complete naval airplane manufactured by Edo. The craft was designed specifically to operate effectively under rough-water conditions.

Basically, the XOSE-1 is a single-place, low-wing monoplane with one main float and two wing-tip floats. Nearly a third lighter than the Navy's most recent scouts, the result in part of the use of a new 75XA aluminum alloy, it features slow-landing characteristics for rough-water conditions yet has a top speed of well over 200 m.p.h. Rate of climb is in the neighborhood of 1,500 ft. per min., while full-load take-off time as a normal scout is approximately 15 sec. Range is approximately 1,000 miles. Power is supplied by a 550-hp. Ranger engine, an inverted V-type 12-cylinder in-line air-cooled engine, which makes possible a narrow and well streamlined nose with excellent vision range forward and down on each side. The entire engine assembly forward of the fire wall constitutes a "power package," attached by four bolts to the fuselage. Installation or removal of the entire power unit can be effected in less than 30 min. All controls and other attachments connect with the fuselage by means of quick-disconnecting couplings. In addition to the "power package" provision of the engine installation, other details of the Edo XOSE-1 have been designed for maximum maintenance efficiency.

To permit housing in the restricted hangar space available on cruisers and battleships, the wings are of the folding type that turn back parallel to the fuselage. The wings may be unfolded in less than 30 sec. Through experience gained during the war with damage inflicted on flap installations by heavy spray during rough-water landings and take-offs, "shock absorbers" are incorporated in the flap mechanism to permit the flaps to retract automatically when hit by water. The spray problem has also been minimized through improved design of the main float which reduces considerably the amount of spray at critical speeds. Full-span automatic slots provide generous antistall characteristics for slow speed in rough-water operations. Effective maneuverability at low speed is achieved also by "drooping" ailerons which, with flaps in full down position, are depressed 15°. Another stress problem involved in rough-water operations was that of attaching the main float to the fuselage strongly enough to withstand the heavy landing impact and the strains occasioned by catapult launchings. The attachment consists of two pedestals without side bracing, which provide the necessary strength with minimum frontal area and drag.

The XOSE-1 is equipped with many devices for observing enemy activity and directing gunfire, as well as for attacking the enemy and defending itself. It is designed to carry forward-firing guns, depth bombs, smoke-screen ejectors, personnel-rescue cells, radar search devices, and others of the Navy's latest electronic developments. Its tanks are of the self-sealing, bullet-proof type, and it carries full protective armor for the pilot. In addition, it is equipped with an automatic pilot. *Edo Aircraft Corporation.*

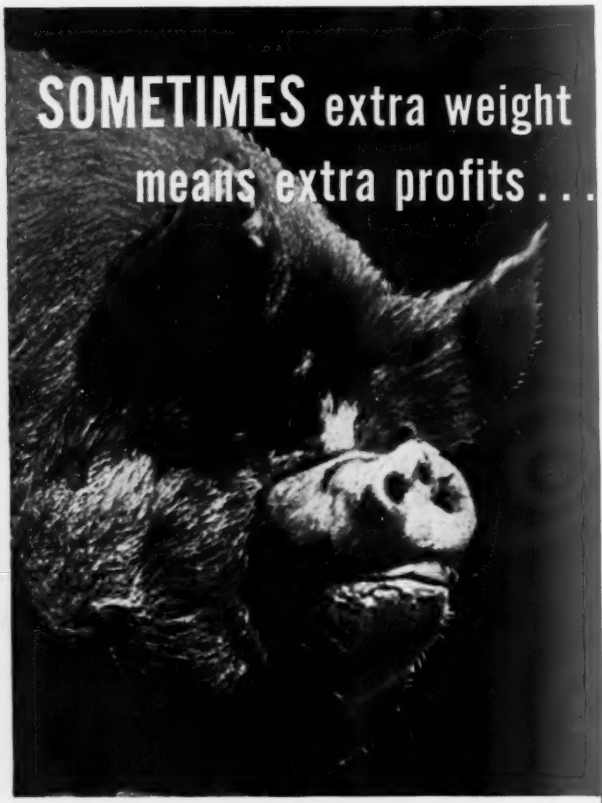
The Edo XOSE-1 scout observation seaplane.

The Lockheed XR-60 Constitution was designed to meet the Navy's need for a large, land-based transport with high speed and extreme range to carry personnel and priority cargo across continents and oceans. Advanced characteristics of the airplane include a wing design which will permit the introduction of gas-turbine power for still greater speed and efficiency when this type of power is available.

The four Pratt & Whitney Wasp Major engines with a combined output of 12,000 hp. enable the XR-60 to carry a useful load of almost 35 tons of passengers and cargo. An innovation in the design is the provision for "in-flight" maintenance of all four engines and most of the mechanical, electrical, and hydraulic fittings. Man-size tunnels within the wings permit inspection and adjustment of engines and accessories. Landing gears, wheels, and brake mechanisms also are easily reached while in flight. In-flight lubrication of most of the mechanical parts is another special service feature. A "one-shot" system permits lubricating oil from a central storage tank to be pumped to each of the four nacelles. Many inspection and service functions normally performed on the ground will be possible in flight, thus lowering the ground time and making possible important reductions in the cost of aerial transportation.

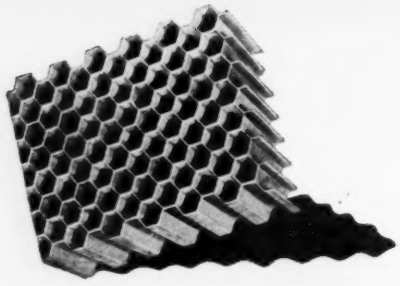
Passengers may be carried on both decks of the Constitution. Generally the upper deck will have seats for 92 passengers while the lower deck, divided amidships by the wing, will seat 76 passengers. Cargo space ranges from 2,000 cu.ft. with 168 passengers to 7,405 cu.ft. when the entire lower deck is used for cargo. Spiral stairways fore and aft connect the two decks. The cabin is fully pressurized to maintain a 10,000-ft. pressure altitude at 25,000 ft. Soundproofing and lighting are of advanced design. A large galley is equipped to serve 300 hot meals on any flight.

A hydraulic booster control system similar to that developed for the Lockheed Constellation provides ease of control. Lockheed-Fowler flaps are fitted and the wing is designed to ensure a minimum stalling speed of 80 m.p.h. Complete navigational radar equipment is installed, and thermal anti-icing is provided for wing and tail surfaces. Landing gear is distinguished by four wheels on each of the main gears. The double nose gear can be steered by the pilot to maneuver the craft on small or crowded landing strips. For efficiency in handling cargo, the airplane is equipped with hoists of 10,000-lbs. capacity which will permit loading and



1. . . . for extra weight in plane construction cuts down pay loads . . . hinders operation . . . reduces airline profits.

That's why the designers of the new Martin 2-0-2 plane took special care to keep this plane's net weight 'way down . . . make it lighter than any other of equivalent horsepower and lifting capacity.



2. This great weight-saving in the Martin 2-0-2 is due to weight-saving engineering involving the extensive use of a lightweight structural material called Armorply Honeycomb . . . for floors, partitions, wing ribs, spars, doors and tank liners.

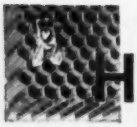
This material has an amazing strength/weight ratio. Weighing less than 4 lbs. per cu. ft., Honeycomb core may be used in sandwich constructions of any practical thickness.

Honeycomb cores (see illustration) may be made of cotton, Fiberglas, paper or other material, faced with aluminum alloys, plywood, stainless steel or decorative plastics. The skins are bonded securely with a new thermosetting adhesive of greater tensile strength than any other material for similar use.

3. Lightweight Honeycomb construction, with its resulting economy, is an important reason why the Martin 2-0-2 has been selected by these leading airlines:

Meantime, Martin engineers are planning still more extensive use of Armorply and Weldwood Honeycomb in their forthcoming jet-augmented plane . . . the Martin 3-0-3.

Detailed engineering data concerning Weldwood and Armorply Honeycomb are now available. Write for full information today.



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unloading at isolated bases where no cranes or platforms are available. Wide cargo doors, 106 by 74 in., are large enough to permit easy access of jeeps. Sixty-foot lengths of pipe, or fighter planes with wings removed, for example, can be loaded in the forward cargo area.

Wing span of the Constitution is 189 ft., overall length is 156 ft., and the tail is more than 50 ft. high. The plane weighs 92 tons, being 11 tons heavier than the Army's C-74, and 20 tons heavier than the Navy's JRM flying boats. Despite its size and weight, its take-off and landing characteristics are comparable with those of many smaller transports. Landing over a 50-ft. obstacle, the airplane can be brought to a stop in only 2,300 ft. For small island air strips where even shorter runs might be necessary, reversibility of inboard propellers will improve the landing performance considerably. The take-off run in calm air at sea level is only 2,350 ft. at maximum gross weight. Maximum ferrying range of the transport exceeds 6,000 miles. Its top speed is 300 m.p.h. *Lockheed Aircraft Corporation.*

Cargo Version of Model 2-0-2 Makes Bid for Supremacy in Aerial Freight Transport. A cargo version of the Martin Model 2-0-2 twin-engined transport is briefly described. The present version will have a gross take-off weight of 41,000 lbs. and an operational range of 1,600 miles, making possible coast-to-coast flights in approximately 14 hours with one stop for refueling. The pay load will be 12,820 lbs., carried in an interior measuring 50½ ft. long, giving 367 sq.ft. of floor space and a total volume of 2,250 cu.ft. It is estimated that operating cost per ton-mile will be as low as $0.06. The modifications of the construction of the Model 2-0-2 for the special cargo version are outlined, as well as the equipment. Power will be supplied by two Pratt & Whitney R-2800 engines, each giving normal take-off of 2,100 hp. with fuel consumption of 191 gal. per hour at 70 per cent power. The airplane will cruise at 10,000 ft. at speeds of 259 to 263 m.p.h. at 70 per cent power, and maximum speeds of 290–292 m.p.h.

Another version having gross take-off weight of 38,000 lbs., maximum range of 1,101 miles, and pay load of 12,885 lbs., also is mentioned. *The Martin Star*, September, 1946, pages 3, 17, 1 illus.

Airplane Design

Jet Fighters. H. F. King. A consideration of technical and operational requirements for jet fighters is presented in regard to existing aircraft and those of the future. The possibilities of athodyd or ram-jet engines as a means of propelling aircraft are discussed. The writer states that endurance and range attainable with the pure jet are being progressively extended by the use of drop tanks, towed tanks, and fueltight wings, and in any case seem to have proved less of a handicap than was originally expected, due in part to an increase in operational height, a condition particularly favorable to the turbine-jet. As an example, the Meteor IV is cited as not only faster at all altitudes than comparable piston-engined machines, but excels in rate of climb and service ceiling. Other relative merits of efficiency are mentioned. The reasons for multijet design are enumerated and the design problems encountered are studied. It is stated that aerodynamic design is not likely to become stabilized for several years. Simplicity and accessibility are offered by mounting the power plant in a nacelle and supporting the tail surfaces on booms. However, at high Mach Numbers this may induce severe down loads on the tail.

The annular intake around the fuselage, with pilot or armament in the nose portion, as in the Miles M52 supersonic project, is mentioned as possibly being indicative of future design. The factors involved in armament installation are examined. Existing armament arrangements are enumerated and relative merits of American, British, and German fighter planes are compared. *Flight*, August 1, 1946, pages 114a–117, 24 illus.

Tailless Aircraft. James Hay Stevens. A brief history of tailless aircraft is followed by a discussion of the aerodynamics problems involved in that type of design. A full-page drawing shows some of the many varieties of tailless aircraft that have been built since 1913. A few of the advantages listed for flying wings are inherent aerodynamic "cleanness" through lack of a tail; comparative thickness of wing due to low aspect ratio; large volume for cargo in big airplanes; favorable arrangement for jet engines; stowage space for retractable landing gear; essential sweepback (or sweep forward) in overcoming compressibility effects. The disadvantages mentioned are design difficulty of coordinating control systems and choice of fin areas; flaps or other high-lift devices change trim to excess; small allowable center-of-gravity movement; large volume available spanwise only, with consequent poor view for passengers; poor directional properties at take-off and landing because of lack of fin area. *Air Reserve Gazette*, August, 1946, pages 11–14, 7 illus.

Doodles for Destruction. Eric Friedheim. Recent design studies produced by the Aircraft Design Branch of the A.A.F. Air Matériel Command at Wright Field are described in brief. The designs fall generally into three classifications. One category includes perimeter-defense types, or interceptors. The second category embraces outer-zone aircraft of the long-range attack-fighter variety which defends the middle zone. Long-range bombers constitute the third design-study class. *Air Force*, September, 1946, pages 50, 51, 7 illus.

Progress in Aeronautics. Sir Ben Locksbeiser. A member of the British Ministry of Aircraft Production reviews the progress made in the design of aircraft during the past 40 years. His comments deal with the evolution of structural design of aircraft, beginning with the wooden frame covered by fabric of the earlier days and advancing to the present metal structure. He proceeds to a consideration of the means of reducing drag, the evolution of laminar-flow wings, recent developments in tailless and all-wing aircraft, and he outlines the work being done in research into flight at and above the speed of sound. The latter part of the paper deals with modern power plants, including the gas turbine, jet propulsion, and rocket engines, comparing the new types of propulsion. Turning to the subject of rotating wing aircraft, the writer reviews the work of the Germans in the design of helicopters and outlines the requirements for successful aircraft of that type. *Nature*, June 15, 1946, pages 787–792, 3 illus.

Power-Folding Problems. The structural designs and power plants employed in British naval wing-folding aircraft are discussed. A recent requirement by the Royal Navy calls for folding and spreading of wings in winds up to 35 knots from any direction in the horizontal plane, and 45 knots from ahead. The operation is to take not more than 15 sec. when the wings are fitted with drop tanks, guns, and bombs, while an alternative method of operation with the engine off also must be provided. Wing-folding geometry takes three different forms: first—the vertical hinge, into which category come all the biplanes and some of the more recent examples of monoplanes; a folding trailing edge is necessary with the monoplanes since otherwise the hinge would come too far behind the rear spar. Second—the horizontal hinge, which usually embodies two hinges, one on each spar, as used on the Seafire and Seahornet. Third—the oblique hinge, the first example of which was the Blackburn Skua, followed by the Roc, and more recently, the Fairey Firefly and Swordfish.

It is noted that the vertical-hinge type of folding wing has now become virtually obsolete, owing chiefly to the difficulties of manufacture and of locking the long joint between the trailing edge and the wing. The horizontal-hinge type has the advantage of reduced area. The greatest disadvantage is that duplicated lifting and locking gear is entailed, and the cen-

ters of gravity of the wing and armament have to be moved through a greater vertical distance. Although the oblique hinge has the advantage of relatively small c.g. movement, the critical case is that of the 35-knot side wind which acts on the flat-plate area of the wing. The three power sources available—hydraulic, electric, and pneumatic—are outlined briefly, while the Lockheed hydraulic system, the method in exclusive use at present, is described at length. *Flight*, July 25, 1946, pages 82, 83, 2 illus.

Simplifying Personal Plane Design. Part II. Ralph H. Upson. The second installment of an article in which information and formulas are supplied as an aid in the work of designing personal airplanes. Conventional or "classical" items of performance largely dependent on power are considered. An easily workable method of power estimation is described. Handy formulas for the engineering department are presented. Sections deal with the power required, the power available, variable and fixed-pitch propellers, maximum propeller efficiency, and the application of the formulas. *Aviation*, August, 1946, pages 71–75, 142, 3 illus.

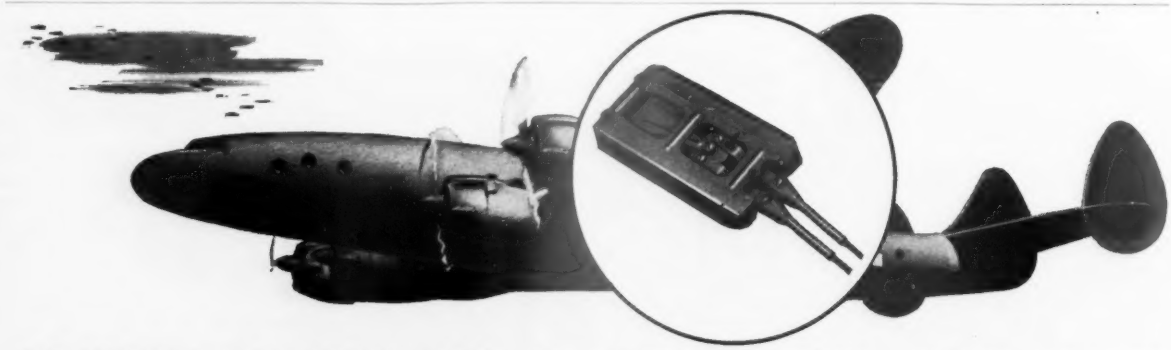
Progress Is a Two-Letter Word. W. E. Beall. The Vice-President of Engineering-Sales of Boeing Aircraft Company looks into the future in an attempt to indicate the expected progress in the aeronautical sciences. He states that the word "if" has a most important bearing on future progress, with regard to the outlook for peacetime development and whether the tempo of research can be maintained during normal times. He indicates that under favorable conditions great progress can be made within the next three decades in atomic propulsion, safe flight at low and high speeds, unlimited range, "foolproof" personal aircraft, automatic controls, and electronic navigational aids. *The Boeing Magazine*, July, 1946, pages 6, 7, 1 illus.

Slow Down! Buck Rogers. Chet Miller. An article based on an interview with the Chief Engineer of the El Segundo Division of Douglas Aircraft Company, Inc., traces the progress made since 1903 in increasing the speed of airplanes. It outlines the research work accomplished in recent years and gives a forecast of the possibilities of supersonic flight in the future, as well as an estimate of the engineering problems involved. It cautions against the acceptance of unfounded predictions of too-great progress in high-speed flight. Charts show the history of the advance in speed achieved by railroads, automobiles, airplanes, artillery missiles, and rockets, as well as records established by commercial and racing vehicles on the surface and in the air. *Douglas Airview*, June, 1946, pages 6, 7, 23, 4 illus.; "Supersonic Flight Poses Many Design Hurdles," *Aviation*, August, 1946, pages 69, 70, 5 illus.

Is Supersonic Flight Around the Corner? A brief review is presented of some of the current and projected designs of aircraft intended to operate at supersonic speeds. The problems of compressibility are discussed briefly in nontechnical language, with specific mention of the Bell XS-1, the Northrop XP-71B, Republic XP-84, North American XP-86, Curtiss-Wright XP-87, and several high-speed bombers. Other engineering projects under study at Wright Field are treated briefly, such as automatic pilot-ejection mechanisms, push-button controls for airplanes, and automatic flight controllers. *The Pegasus*, August, 1946, pages 1–5, 16, 10 illus.

Avigation

"The Final Approach." Capt. V. A. M. Hunt. Details of the present attempts to solve the problems of instrument landings are discussed, as well as prospects for the future. A list is supplied of the requirements demanded of "blind-landing" approach instruments and existing equipment specifications are compared. It is pointed out that the S.C.S. 51 American V.H.F. instrument-landing system is the most practical but that it fails in the continuous-distance specification. The British Babs Mark II beam approach beacon system fails



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with regard to the glide path and direct interpretation. These instruments are explained and their methods of operation are illustrated by diagrams. The Ground Control Approach (G.C.A.) and the fully automatic approach systems also are mentioned, the latter being considered the coming method for final approach. *The Log*, July, 1946, pages 110–117, 2 illus.

An Evaluation of Hyperbolic Radio Avigation. Operational data for five hyperbolic avigational systems are compiled in table form and accompanied by a brief comparison with standard loran. The others are skywave synchronized (S.S.) loran; low-frequency (L.F.) loran; and the British Gee and Decca systems. Hyperbolic radio lines of position are favored by the writer for regularly scheduled long-distance flights because they provide a distinct coordinate system comparable to the coordinates of longitude and latitude, and because they are physically real, not merely arbitrary lines on maps. The article explains the operation of the systems with regard to rate and accuracy; base-line distance; pulse length in microseconds; and radio carrier frequency. *Aviation*, August, 1946, pages 51, 149, 1 illus.

Comfort in Aircraft

Soundproofing Lightplanes. W. J. Connell. The writer briefly states his experiences in soundproofing a light plane. The recommended method for installation of Fiberglas is outlined. It is suggested that strong cord be criss-crossed through and in front of the Fiberglas, and between ribs and bulkheads, to assure that vibration will not eventually shake the substance loose. A series of photographs illustrates the procedure. *Southern Flight*, August, 1946, page 61, 5 illus.

Control Systems

The Frequency Response of Automatic Control Systems. Herbert Harris, Jr. The paper illustrates the advantages of the frequency-response approach to the analysis of automatic control systems, such as servomechanisms, as contrasted with the analytic solution of transient responses. At the same time the equivalence of information available from the two approaches is demonstrated. A numerical example is given based on a torque amplifier using a motor-generator type control. The frequency analysis is based on the mathematics of the Fourier series, and it is shown that the Fourier integral provides information equivalent to the transient analysis but with much less calculation and with more easily interpretable results. *Electrical Engineering*, August-September, 1946, pages 539–545 (Transactions), 13 illus.

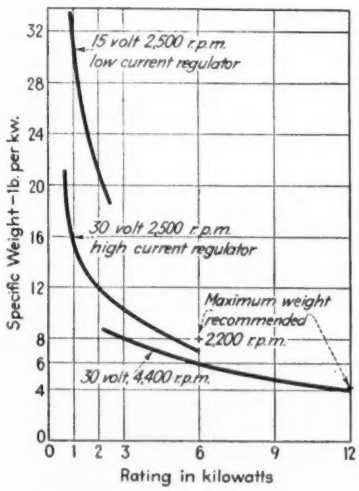
German Aircraft Hydraulic Systems and Their Components. R. H. Davies. Information about the design of hydraulic systems used on German aircraft is presented, with particular attention to features and products that appear to be new in design, unique in construction, or which might have application to current developments in the United States. Sections are devoted to a general review of German practices and policies with regard to design and manufacture; basic design features of German systems; representative hydraulic systems as installed in three of the latest German airplanes; design and operation of hydraulic systems of different planes and manufacturers; German hydraulic developments in relation to American practice. Diagrams of different types of hydraulic systems are shown and sectional views of various components are included. *SAE Journal*, August, 1946, pages 418–435 (Transactions), 28 illus.

Electrical Equipment

Lightweight Electrical Systems Design Problems and Solutions. T. B. Holliday. Consideration is given to weight reduction in aircraft electric systems. Various electric systems are described and design practices are compared with those used in the development of industrial electrical equipment. The effect of voltage on the weight of the wiring in aircraft is examined. The distribution of weight in three sizes of military aircraft is studied with the aid of curves and diagrams. The influence of cooling on weight also is considered. *Product Engineering*, August, 1946, pages 122–126, 6 illus.

Engines, General

Thrust. This article illustrates in color photography and diagrams the main features of turbojet, pulse-jet, ram-jet, and rocket engines, and explains the theory and operation of these power units in nontechnical language. The brief introductory text defines jet propulsion and thrust. *Fortune*, September, 1946, pages 128–140, 28 illus.



Reduction of generator weight obtained by changing the type of voltage regulator and by doubling the generator speed. (See "Lightweight Electrical Systems. . . . ")

Napier Flight Development. A detailed report about the equipment and the work being accomplished at the Napier engine-installation experimental establishment at Luton Municipal Airport, England, is preceded by a brief history of that department before its transfer to Luton, in 1940. The writer describes the current research work and examines other projects under way. Included among the projects studied were the annular radiator installation for the Tempest and similar experimental installations in a Warwick; the ground and airborne versions of the Napier-designed ignition tester; automatic camera recorder; destruction and stiffness tests on a Sabre engine mounting as developed for the Firebrand; photographic determination of position error; and a momentum-type air cleaner produced for the Typhoon. *Flight*, July 25, 1946, pages 90a–93, 15 illus.

Japanese Aero-Motor Developments. Information is supplied about Japanese aircraft power plants, including jet propulsion and rocket developments. The Japanese Army and Navy systems of naming and designating aircraft engines are explained. The characteristics of important Japanese Army and Navy air-cooled and liquid-cooled engines in service or about to come into service when the war ended are outlined. A table contains the general specifications of these engines. *The Aeroplane Spotter*, August 10, 1946, pages 186, 187, 2 illus.

Thermodynamic Charts for the Computation of Combustion and Mixture Temperatures at Constant Pressure. L. Richard Turner and Albert M. Lord. Charts are presented for calculating the combustion temperatures and the temperature changes involved in constant-pressure thermodynamic processes of air and the products of combustion of air and hydrocarbon fuels. Examples are given in which the charts are applied to the calculation of the quantity of fuel required for combustion to a given temperature, the increase in the temperature of products of combustion by the introduction and combustion of additional fuel, the change in enthalpy of the products of combustion with change in temperature, the equilibrium temperature resulting from the mixing of two gases representing products of combustion, and the temperature resulting from the afterburning of richer-than-stoichiometric exhaust gases with additional air. The charts are applicable only to processes in which the final fuel-air ratio is leaner than stoichiometric and at temperatures where dissociation is unimportant. They may be

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Another Douglas First, these new brakes slow the Skyraider to less than 300 mph in vertical dives. In addition, they contribute to superb control in maneuvering, fighting and letting down.

applied to steady-state flow processes. *National Advisory Committee for Aeronautics, T.N. No. 1086,* June, 1946.

Engines, Gas Turbine

De Havilland Goblin II. Part II. J. A. Oates. Additional details about the production methods used in the manufacture of de Havilland Goblin II gas turbine-jet aircraft engines are presented. The manufacture of the turbine blades is described. Information is supplied about the procedure for assembling the turbine and stator blades and the fixed diaphragm unit, the machining operations on certain other components, and the test rigs installed in the shop. The operational sequence for the turbine blade is listed in tabular form. Illustrations of machine tools and machining operations are included. *Aircraft Production,* August, 1946, pages 386–398, 37 illus.

The Future of the Gas Turbine. Wing Comdr. A. E. Louks. The economic and technical aspects affecting the gas-turbine engine are studied in a paper which examines the future of this type of power plant. The writer feels that the needed increase in power for subsonic cruising speeds will entail a serious economic drawback unless there are sound methods of reducing the cost per passenger-mile. Four subjects involving reduction of costs in high-speed travel are outlined as (1) atomic energy harnessed to the gas turbine; (2) the use of the laminar-flow wing with the jet; (3) pressure cabins permitting operation at the necessary altitudes; (4) the substantial increase in pay load as a percentage of total weight when compared with conventional piston-engine and propeller combinations. General uses of the gas-turbine engine for surface transportation are mentioned. *Air Reserve Gazette,* August, 1946, pages 1–6, 14 illus.

Engines, Ram-Jet

Ram Jets. Reference is made to an announcement by the Navy Department of a flying model driven by a ram-jet engine made from the tail pipe of a P-47. The model has been flown at speeds exceeding 1,400 m.p.h. The principle on which the ram-jet engine operates is explained, and ways of assaying the performance of ram-jet engines are outlined. Pulse-jet engines also are discussed. Consideration is given to the future possibilities of the ram-jet engine. It is stated that its greatest suitability is for supersonic aircraft, either piloted or pilotless. Because of its light weight and ease of fabrication, it may be used also for subsonic expendable missiles. The third possible application is for rotating wing aircraft where rotor wing-tip speeds may approach the speeds desired for ram-jet operation. *Product Engineering,* August, 1946, pages 140–142, 4 illus.

Athodyds for Aircraft. The general characteristics of athodyds or ram-jet engines, and the possible application of this type of power unit to aircraft are discussed. The handicaps of the athodyd are listed as: the high fuel consumption; the necessity for providing supplementary launching power (the static thrust being zero and the take-off thrust negligible); and, by comparison with rocket propulsion, an inferior climb performance. A graph shows the thrust per sq.ft. of frontal area of a high-output turbine-jet compared with that of an athody.l. German and French developments in this field are reviewed. *Flight,* August 15, 1946, pages 155–157, 7 illus.

Engines, Reciprocating

The Cold Starting of Aero-Engines. Flight-Lt. C. G. Pickering. An analysis is made of problems connected with the cold starting of aircraft engines of the reciprocating type, and of the conditions that limit the satisfactory operation of the engine after the initial start. The general problem of cold starting is classified into cranking, priming and carburetion, oil dilution, and ignition. Each of these subjects is considered in some detail. Cranking methods discussed include a.c. and d.c. electric starters, inertia-type electric starters, and small gasoline-engine starters. The procedure for carrying out cold-starting tests is described. *Aircraft Engineering,* August, 1946, pages 259, 260, 263.

Two New Power Units. Brief specification data are supplied for the Napier Sabre Mark VII piston engine, and for the Rolls-Royce Merlin Mark 620. The Napier Sabre Mark VII has provision for water-methanol injection and is said to be basically the same as the Mark V although it is capable of developing more power. The engine's maximum power with water-methanol injection is 3,050 b.hp. at 3,850 r.p.m. plus 17¼ lbs. boost. The Rolls-Royce Merlin Mark 620 is said to embody the latest Merlin features, including gasoline injection, and is of the two-stage supercharger, intercooled type. The radiator system is a development of the Avro Lincoln installation and has the same characteristic appearance. *Flight,* July 25, 1946, page 99, 3 illus.

Torsional Vibration of Crankshafts: Analytical Note on Dynamic Absorbers. B. C. Carter. The effects on torsional vibration of having a flywheel-mass elastically connected to the tail shaft of an idealized single-throw engine have already been examined analytically as described in *R. & M. No. 1053,* "Torsional Vibration in Engines: Effects of Fitting a Damper, a Flywheel, or a Crankshaft-driven Supercharger," February, 1926. A simple extension of this analysis gives the basic formulas for the functioning of an undamped pendulum mass, or its equivalent, fitted to such an engine. The effects of damping the mass in such an instance can be studied by making a suitable extension of the analysis given in Part II of *R.A.E. Report No. E.3586,* "Torsional Vibration in Aircraft Power Plants: Methods of Calculation." *British Ministry of Aircraft Production, Aeronautical Research Committee R. & M. No. 1973.* British Information Services, New York, $0.30.

The Influence of Engine Variables on Exhaust Valve Temperatures. The variables that affect the calculation of exhaust-valve temperatures are discussed at considerable length. The factors that cause distortion of the contour of the valve seat, the influence of the guide-boss design, and the design of the valve itself are outlined. Other factors that have a bearing on the subject are the fuel-air ratio, the engine speed, and the mean effective pressure. With the aid of charts and drawings, the writer explains the temperature pattern and the effect of the type of combustion on the operating temperature. *Wil-Rich Forum,* July, 1946, pages 1–4, 7 illus.

Engines, Rocket

German Developments in the Field of Guided Missiles. Col. D. L. Putt. Reference is made to the great effort in basic research expended by the Germans in the guided-missiles field. It is stated that wind tunnels of extreme speeds were under construction when the war ended, and that a Mach Number of 10 was not too great for the Germans to comprehend and strive for. The various types of developments in "guided missiles" (which, it is noted, is a loose term, since some are not guided and some are not missiles), are discussed in considerable detail. Weapons of this type are classified and described. *SAE Journal,* August, 1946, pages 404–411 (Transactions), 14 illus.

Flight Technique

Landing on Arctic Ice Fields. Meldrum S. Young. A brief account of the research findings of the Arctic Section of the A.A.F. Center in Orlando, Fla., is concerned with the study of aircraft landings on natural ice. It is stated that fresh-water ice, such as a frozen-over Arctic lake or river, is approximately three times as strong as salt-water ice. Old ice that has been growing thicker throughout a winter is said to be safer than new ice. It is concluded that no airplane should attempt to land on ice less than 6 in. thick. Other suggestions are given for the identification of ice surfaces on which it is safe to land, and for making landings on ice. *Log of Navigation and Aviation,* August, 1946, pages 26, 27, 1 illus.

Flight Testing and Performance

The Jet Plane Goes to Sea. Comdr. John B. Goodman. An observer gives an account of the XFD-1

Phantom jet-propelled plane's first six take-offs from an aircraft carrier, the U.S.S. "Franklin D. Roosevelt." The difficulties that were overcome by engineers in adapting jet planes to carrier operations were (1) perfecting a plane that could take off in the short length of the usable portion of the flight deck; and (2) developing a power of acceleration in the engines so that a plane could make a second approach should the deck not be clear for a landing. The specifications of the Phantom are outlined briefly. *U. S. Air Services*, August, 1946, pages 10–12, 1 illus.

A Blown-Up "Wimpey." D. W. Lucke. High-altitude experiments made between 1941 and 1944 by Vickers-Armstrongs, Ltd., are related, with particular reference to the pressure chambers installed in the Wellington V and VI and the effects of low temperature upon the control equipment. A complementary test program being conducted by Rolls-Royce Ltd. also is mentioned. *Flight*, August 8, 1946, pages 129, 130, 2 illus.

Fuels

Development of Reference Fuel Scales for Knock Rating. Donald B. Brooks. The development of the measurement of knock rating which has occurred during the past 25 years is reviewed. Reference is made to several means of extending the octane-number scale which have gained limited acceptance, and to the fact that experimental fuels have now exceeded the range of these systems. Information is supplied about a proposed "triptane scale" and interchangeable detonation index, both extensible to the upper limit of anti-knock quality. It is stated that research now in progress may be expected to provide information on which adoption of this scale can be based. *SAE Journal*, August, 1946, pages 394–403 (Transactions), 12 illus.

Rocket Engine Fuels. Robert McLarren. The characteristics that a rocket fuel must possess in order to find wide application in warfare are enumerated. It is noted that rocket fuels fall into two physical classes—solid and liquid; and into two chemical classes—monofuels and bifuels, the former depending upon the surrounding air for its source of oxygen for combustion. Generally, solid fuels are being specified for short-range rockets. Liquid fuels predominate in the long-range rocket field. The principal advantages of solid fuels for rocket propulsion are listed and particulars are given about the different kinds of solid fuels. Some of the research work that has been carried out on liquid fuels is mentioned. It is stated that research is now being directed toward the development of bifuels containing their own oxygen supply, which are suitable for use even in outer space and permit the rocket to develop maximum power. The characteristics of some liquid fuels are listed. *Automotive and Aviation Industries*, August 15, 1946, pages 20–23, 76, 3 illus.

Gliding and Soaring

Silent Flight. Sanford A. Wolf. A chronological account of gliding and soaring achievements and records throughout the world is prefaced by a report on gliding activities at Elmira, N.Y. Developments beginning with hill-slope gliding and advancing to winch launching and to airplane-towed gliders are traced. The names of fliers, dates, locations, and aircraft descriptions are supplied. *Air Force*, September, 1946, pages 38–42, 7 illus.

Thermal Soaring. Squadron-Leader E. J. Furlong. The fundamentals of soaring-flight technique are presented in a list of 22 instructions explaining the nature of thermals and the recommended manner in which to utilize their upward force. A series of ten diagrams attempts to reveal the physical structure of these rising currents of air. *Air Reserve Gazette*, August, 1946, pages 26, 27, 10 illus.

History

There Were Giants in Those Days. William Friedman. A chronological report about a number of large aircraft built in the United States and in Europe begins with Igor I. Sikorsky's four-engined biplane called the Grand, built in 1912. In general, the account deals with the design and construction of these older aircraft, the reasons for their failure, and their contribution to later developments. The history of German lighter-than-air craft also is reviewed. *Air Force*, September, 1946, pages 19–23, 62–64, 15 illus.

AAF Chronology. Sgt. Vivian L. Schectman. An outline of important dates and events in the history of technical developments for the Army Air Forces and its predecessors, beginning July 1, 1907, and extending to 1939, is prefaced by a review of the historic and legendary attempts at flight made as far back as 1500 B.C. The subjects pertaining to technical developments include aircraft design; design modifications; inventions of parts and accessories; radio communications; aerial photography; record flights; and engineering. *AAF Review*, August, 1946, pages 40–47, 14 illus.

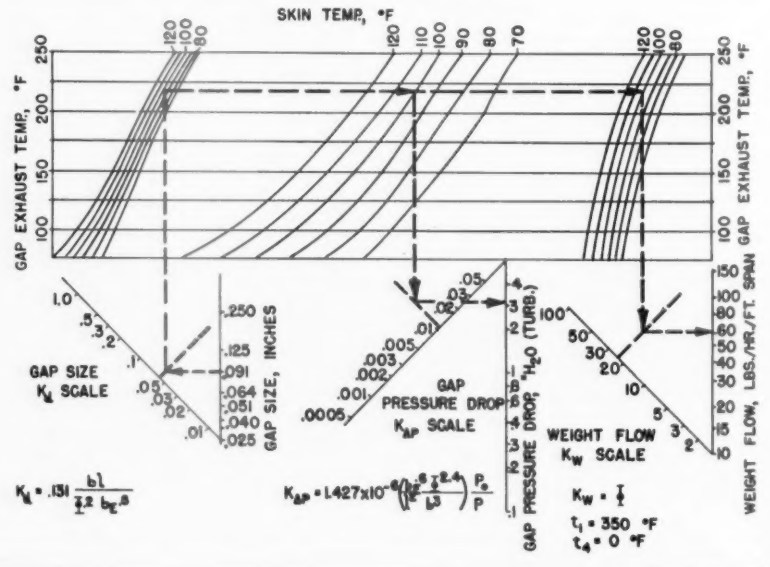
Hydraulic Equipment

Fluid Power Transmission in Aeroplanes. D. G. A. Rendel. A preliminary attempt is made to break through the mass of practical design and functional difficulties at present apparently unavoidable in aircraft fluid power transmission, in order to provide a more fundamental approach to the subject. Consideration is given to problems connected with the supply of power, either by conversion from rotational energy or otherwise, in a form in which it can be transmitted to and used in other parts of the aircraft; the transmission of converted energy; and the reception and use of converted energy. *Aircraft Engineering*, July, 1946, pages 237, 238, 241.

Ice Prevention

Icing Problems and the Thermal Anti-Icing System. F. L. Boeke and R. A. Paselk. In the design of the thermal anti-icing system the number

Design chart for determination of gap size, gap pressure drop, and weight flow for a constant supply or temperature. (See "Icing Problems. . . .")


SKIN TEMP, °F
GAP EXHAUST TEMP, °F
GAP SIZE K_L SCALE
GAP SIZE, INCHES
GAP PRESSURE DROP K_ΔP SCALE
GAP PRESSURE DROP, "H2O (TURB.)
WEIGHT FLOW K_W SCALE
WEIGHT FLOW, LBS./HR./FT. SPAN
K_L = .131 bl / ∛2 b_E^.8
K_ΔP = 1.427x10^-6 (h^2.8 ∛2.4 / b^3) P_s/P
K_W = 1
t_1 = 350 °F
t_4 = 0 °F

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Center of this development work is the G-E Flight-test Division which was recently dedicated at Schenectady. Besides the huge hangar, there are offices for engineers, a workshop where parts are made, and space for development work on all types of air borne equipment. Here, work begun under the impetus of war years has not slackened on equipment useful in commercial aviation. Here, too, problems connected with new planes of all types can be studied and equipment flight tested. Remember, General Electric is working on electric power systems (a-c and d-c), aircraft instruments, gas turbines, and many other devices. Perhaps we have the answers to your electrical problems. Our engineers will be glad to discuss them with you. ***Apparatus Dept., General Electric Company, Schenectady 5, N. Y.***

GENERAL ELECTRIC

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of variables to be considered usually requires a lengthy analysis which, if the effect of the variables is not fully understood, may result in errors in heat required and unnecessary system weight. A study of the effect of altitude and air speed on the heat required, pressure available, and pressure required shows that the maximum heat requirement occurs at sea level at some air speed not necessarily the maximum for the airplane. This maximum design speed is influenced by the adiabatic heating effect. A further study shows that in designing the ducting system to provide the proper airflow quantities, sea-level and minimum air-speed conditions should generally be used. The design of the air passages or gap adjacent to the surface to be heated usually requires a cut-and-try procedure. In this paper a chart is shown which readily evaluates the effect of varying the gap size and the supply air temperature on the surface temperature, weight flow of air required, and gap pressure drop. Additional charts provide a means of selecting the optimum combination of gap and supply duct system pressure drop which results in a system of minimum weight and heat requirement. *Journal of the Aeronautical Sciences*, September, 1946, pages 485–497, 19 illus.

Instruments, General

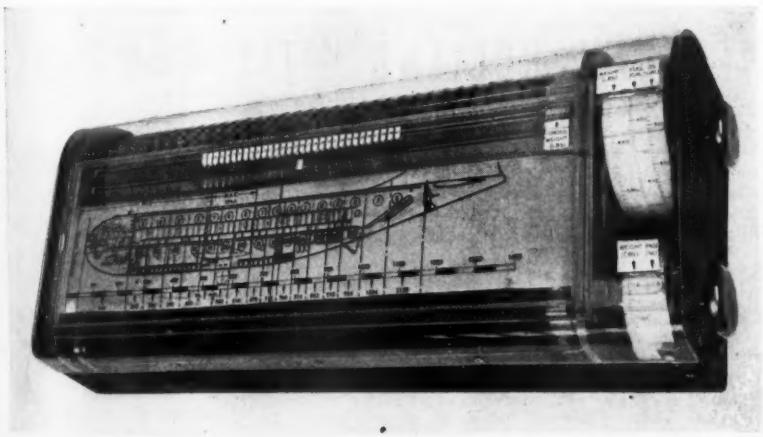
Load Computer. Margaret Young. An instrument developed by Boeing engineers for rapid and accurate computation of the center of gravity of an airplane is explained in brief. Although designed primarily for use in the Boeing Stratofreighter, it can be adapted for use in stowing cargo on any transport of similar size. The face of the instrument contains a profile of the airplane and a large pointer is used to indicate the position where cargo is being stowed. For computing a particular load condition, the basic weight of the airplane and the known c.g. are recorded on the machine. Then the weight of the additional load being added is recorded and the pointer is moved to the section of the airplane where cargo is being put aboard. The machine automatically shows the new c.g. and the total airplane weight. With the c.g. determined after the first truckload of freight is stowed, it is possible to determine what section of the aircraft should receive the next batch. *Boeing Magazine*, August, 1946, page 13, 2 illus.

Dramatizing an Industry. R. E. Gillmor. The Vice-President of the Sperry Corporation describes a novel form of exhibit used to illustrate the design, manufacture, and application of the products of the Sperry Gyroscope Company. The exhibit provides a means for relating the fundamental institutional purposes of the company and demonstrates some of the basic phenomena of the four engineering fundamentals upon which the company's products are based, namely: gyroscopes, electronics, automatic computation, and servomechanisms for remote indication and control. Recorded narration traces the evolution of mechanical devices and ingenious exhibits demonstrate the application of fundamental engineering principles to the progress of mankind. *Sperryscope*, August, 1946, pages 2–5, 7 illus.

Instruments, Flight

Airspeed Conversion Chart. R. F. Boehme. A description is given of a mechanical computer and nomographic conversion chart for obtaining true air speed from the known factors of indicated air speed, temperature, and altitude, or the reverse. The computer is made of Lucite sheet approximately $^1/_{16}$-in. thick and has slots corresponding to the nomograph scale, with graduations engraved alongside the slots. Sliders are arranged to run in the slots and Lucite links are pinned to the sliders in such a manner as to duplicate the operations performed graphically on the nomogram. The computer obviates the use of triangles, straight edges, and pencils in connection with the nomograms. *Aero Digest*, August, 1946, pages 85, 162, 2 illus.

The Boeing center-of-gravity computer. (See "Load Computer.")



Instruments, Meteorological

Sounding Rocket Radio Sonde. A. E. Crawford. The design of a radiosonde for a meteorological sounding rocket is stated to be basically similar to that of the equipment used at present in sounding balloons, with certain exceptions. The exceptions are considered briefly by examining the methods used in these radiosondes and by the factors involved when applied to rocket sounding apparatus. The factors affecting the design of the transmitter are listed, including weight, power supply, operation at low temperature, operation at low pressure, and economy in manufacture. A typical transmitter layout is described and its electrical circuit is sketched. Existing meteorographs are discussed, with recommended modifications for rocketsonde operation. *Journal of the British Interplanetary Society*, June, 1946, pages 8–12, 3 illus.

Landing Gear

Landing Gear for Jet Fighters. Kenneth J. Key. Design trends in landing gear for jet-propelled fighters are discussed in conjunction with other structural factors involving landing operations. The problem confronting the landing-gear designer for fighters is reviewed briefly. Problems of space for retractable landing gear, as well as the type and position of the landing apparatus that offers the best aerodynamic control in regard to the c.g. and ensuing pitch control, are discussed. Questions of balance and the effect of the jet blast on airport surfaces also are considered. Specific examples and comparisons of German and British designs are supplied. Inasmuch as wings are becoming thinner and landing gear must be housed in the fuselage, these factors have a great influence on landing-gear design. This evolution is noted by a series of examples beginning with the Gloster E.28/39. Flap operation, in connection with landing operations, also is examined. *Flight*, August 8, 1946, pages 134–137, 8 illus.

Lubrication and Lubricants

Keeping Pace with Lubricants. H. A. Murray and E. V. Albert. The application of improved lubricants and better lubricating practices to the lubrication of air-frame components and engine accessories is the subject of this article. Currently used aircraft greases are classified as general-purpose, low-temperature, high-temperature, and graphite greases, each of which is discussed. Applications of aircraft specialty oils and hydraulic

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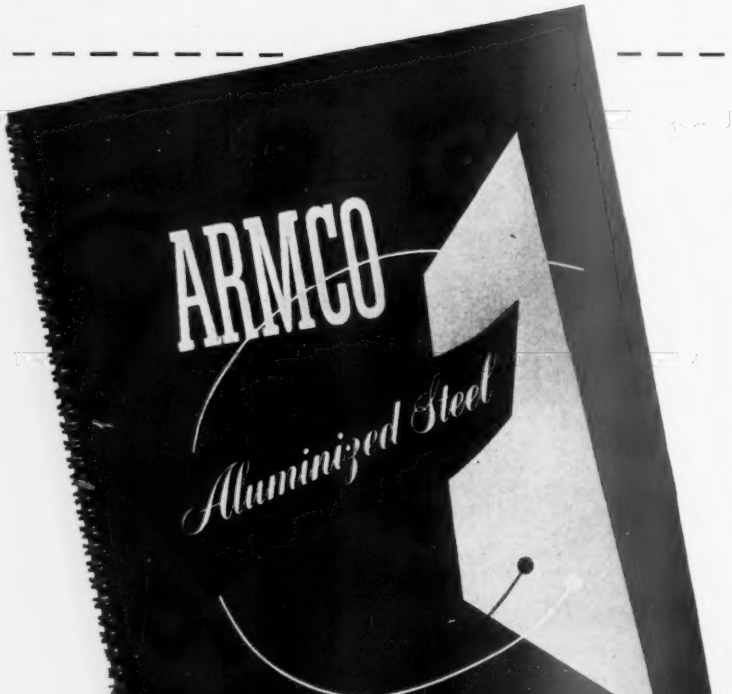

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oils also are considered. A summary of aircraft lubricants presented in tabular form gives the types of lubricants, specification numbers, service applications, and general characteristics. *Aviation Maintenance & Operations*, August, 1946, pages 22–26, 82, 84, 86, 88, 90. 9 illus.

Maintenance

Overhaul Procedures. J. F. Nycum. Delta Airline's overhaul organization is described with reference to the procedures followed in maintaining DC-3 and DC-4 airplanes at the company's shops in Atlanta, Fort Worth, and Miami. An organization chart, headed by the Vice-President-Operations, illustrates the manner in which the maintenance group functions. The writer states that successful operation of the system depends largely on a mutual working basis for the three primary sections, Maintenance, Engineering, and Inspection. Subdivisions of these groups and their functions are discussed. The description is accompanied by comments offered by maintenance officials of three other air lines. *Air Transport*, August, 1946, pages 36–39, 6 illus.

Maintaining the Champion Should Prove Easy. Maintenance procedures for the Aeronca Champion are detailed. Provisions for easy maintenance, incorporated in the design of that light plane, are enumerated. The method of fabric attachment for the wings, ailerons, and tail surfaces is cited as an example. Instead of using rib stitching to hold the envelope in place, the fabric is positioned on the frame, a strip of $^3/_4$-in. pinked tape is laid down across the fabric and rib, and the fabric is attached to the frame by screws whose heads are then covered by a strip of pinked tape "doped" to the fabric. Maintenance instruction is supplied for wing rigging, control cables, landing gear, tail surfaces, and the 65-hp. Continental four-cylinder engine. An annotated diagram explains the lubrication system. *Canadian Aviation*, August, 1946, pages 72, 74, 76, 3 illus.

Life Expectancy of an Accessory. George Herrick. Information obtained about overhaul times and costs on aircraft accessories for each of a number of air-line companies in the United States has been compiled in table form. The accessories examined are hydraulic pumps; vacuum pumps; fuel pumps; propeller-feathering pumps; propeller governors; starters; generators; magnetos; and propeller-feathering motors. The writer attempts to analyze some of the major variations in cost and time for maintenance work on identical parts reported by different companies. *Air Transport*, August, 1946, pages 62, 63.

Check Chart: Airplane Check-Out Data. A chart is presented outlining various limitations for the operation of the engines of Douglas Aircraft, pertaining to DC-4 and DC-4 conversion aircraft equipped with Pratt & Whitney engines of the R-2000 series. It gives maximum and minimum cylinder-head temperatures, fuel and oil pressures, carburetor air temperatures, speeds, manifold pressures, and power tolerances. In addition to engine data, limits are suggested for trim-tab settings, wing-deicer pressures, hydraulic-system data, and instrument tolerances. *Douglas Service*, August, 1946, pages 6, 7.

Materials, Metals and Alloys

Tensile Properties Affecting the Formability of Aluminum-Alloy Sheet at Elevated Temperatures. A. E. Flanigan, L. F. Tedsen, and J. E. Dorn. The tensile properties thought to influence formability have been determined for 15 aluminum-alloy sheet materials tested at elevated temperatures. Complete load-extension diagrams have been obtained, and the effects of temperature, strain rate, and exposure time have been noted. An appreciable increase in the elongation over a zero gage length is found at elevated temperatures. This suggests that forming operations in which this property is a criterion may be facilitated at such temperatures. A decrease in the limit of uniform elongation is noted at elevated temperatures, suggesting that operations in which this property is a criterion may be less successful. A fiftyfold change in strain rate has an appreciable effect on properties at the higher temperatures, an increase in strain rate appearing to be equivalent to a decrease in temperature. In the case of materials subject to precipitation hardening, the time at temperature appears to be a minor factor for times ranging from 5 to 20 min. and temperatures up to at least 450°F. In certain cases unusual load-extension diagrams were noted. *Journal of the Aeronautical Sciences*, September, 1946, pages 457–468, 36 illus.

Temper Embrittlement of Aircraft Steels. P. A. Haythorne. Data are presented concerning the effects of tempering temperatures on the impact properties of several aircraft steels. The results of Charpy, Izod, and tension-impact tests are illustrated by correlated curves that indicate the variation in degree of embrittlement of susceptible steels when tempered in critical temperature ranges. The application of these data to design and process specifications is briefly discussed, as well as the need for modification of present specifications which attempt to specify a "universal" minimum tempering temperature. *The Iron Age*, August 29, 1946, pages 51–55, 8 illus.

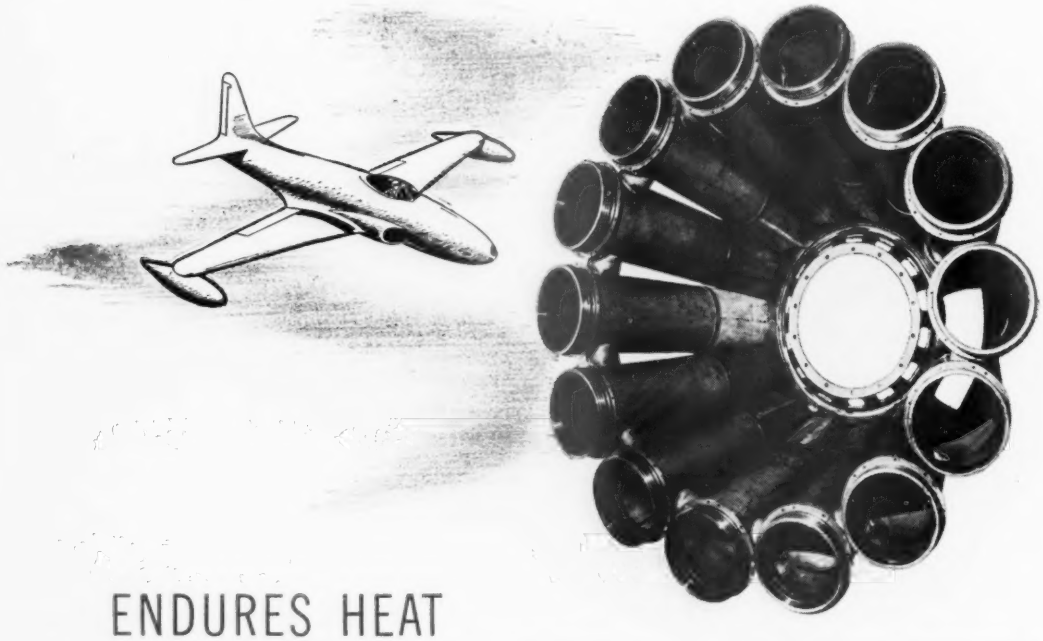
Development of D.T.D. 424. G. D. Chapman. The writer summarizes the course of evolution of the aluminum-silicon-copper alloy designated as D.T.D. 424, now a popular foundry alloy. Early difficulties encountered in its practical introduction are described. How these difficulties were overcome is explained. *Light Metals*, August, 1946, pages 398–400.

Alloys of the Heavy Metals. G. Fitzgerald-Lee. Recent developments in that branch of metallurgy which has to do with the heavy metals are reviewed. Advances in powder metallurgy are described and information is supplied about the properties of tungsten and tantalum. The use of heavy metals as a screen to limit the diffusion of harmful radiation from radium is discussed. Reference is made to compounds of the heavy metals which are of value in industry. A material known as G.E.C. Heavy Alloy, a product of the research laboratories of the General Electric Company, Ltd., is described. This is a powdered metallurgy product which is stated to be as strong as steel but twice as heavy. Advantages of the new alloy are outlined and it is explained that despite its weight it has certain aeronautical uses. *Aircraft Engineering*, July, 1946, pages 239–241, 4 illus.

Triple Alloy Structural Tubing. C. M. Schwitter. Factors that have led to the adoption of tubing made from 8630 steel, one of the so-called triple-alloy steels, by the aircraft industry as a peacetime engineering material, are discussed. These include strength, formability, weldability, and consistent hardenability. Particulars are supplied about the effect of heat-treatment on the physical properties of various sizes of steel tubing. The results of weldability tests conducted under various conditions are given. An aircraft engine mount fabricated from 8630 steel tubing is illustrated. *The Iron Age*, August 22, 1946, pages 46–49, 4 illus.

Some Properties and Applications of Aluminized Steel. Aluminum-coated steel and its applications in various industries including the aircraft industry are treated in this article. It is explained that aluminized steel is produced by applying molten aluminum to both sides of a steel sheet by a patented process, and that the product combines many of the advantages of both metals. Particulars are given about the gages available, the drawing and welding properties, resistance to corrosion, and heat-resisting qualities. An aluminized steel fire wall for aircraft is illustrated. *Modern Metals*, August, 1946, pages 14–16, 6 illus.

Behavior of 18-8 Ti-Stabilized Stainless. Ernest H. Wyche. The behavior of stainless steels is discussed in a two-part article. Part I describes various means for detecting and combating intergranular corrosion. The effects of the stabilizing elements, titanium and columbium, on the physical properties of wrought 18-8 stainless steels also are considered, together with precautions to be observed in calculating proper ratios of these elements for best results. In Part II the effects of temperature on the physical properties and creep strength of columbium- and



ENDURES HEAT

Burner for jet engines made of stainless steel

This assembly of 14 combustion chambers is part of a jet engine through which fiery gases flow at temperatures over 1,500 degrees Fahrenheit. To withstand these high temperatures, and also the corrosive attack of the combustion products, this entire burner unit and various accessory engine parts are constructed of stainless steel. This ideal combination of heat endurance and corrosion resistance makes stainless steel the best metal for countless other types of equipment too — ranging in size and shape from huge chemical reaction towers to frying pans for your kitchen stove.

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titanium-stabilized types of 18-8 stainless steels are considered. Weldability, corrosion resistance, and stabilization heat-treatment are compared from the point of view of determining suitable commercial applications. *The Iron Age*, August 8, 1946, pages 61–65, 1 illus.; August 15, 1946, pages 54–56, 4 illus.

Materials, Plastics and Plywood

Dufaylite. Dufaylite is a low-density material designed to combine lightness with strength. Consisting of a number of resinated paper cells bonded between two thin skins of any material, such as plywood, aluminum, or plastic, it forms a new laminate that is said to possess a high compression strength. It is stated that Dufaylite is structurally stronger than any other material of the same weight yet discovered. The material is intended for use on aircraft for internal cabin construction, shock absorption, thermal insulation, and for acoustics. *British Plastics*, July, 1946, pages 327–329, 5 illus.

Materials, Protective Coating

Anodizing and Its Uses in Engine Construction. The article, a translation of an account by N. D. Tomashov in *Vestnik Inzhenerov i Teknikov*, No. 2, 1946, is concerned with the practice and control of anodizing, with special reference to the production of films of value in the development of improved service characteristics in aircraft engines. The writer discusses the mechanism of the anodic process and its principles, the physical and chemical properties of anodic oxide films, and the possibilities of using anodizing in aircraft-engine construction.

Advantages that may be realized from anodizing the piston crown, cylinder head, and cylinder are discussed. Possible applications of anodic oxide films to electrical auxiliary apparatus also are discussed. *Light Metals*, August, 1946, pages 429–438, 4 illus.

Medicine

Physical Fatigue in Single Control Military Aircraft. Comdr. Howard R. Bierman. An investigation of physical fatigue of pilots operating single-control military aircraft is reported. It was found that the three major components of this type of fatigue are discomfort of the buttocks, discomfort of the back, and a sciatic-like syndrome of the legs. One hundred and sixty-six pilots of five carrier squadrons were studied for symptoms of physical discomfort while flying, and the types and time of appearance of the complaints were classified. Some aids for relief from these discomforts are suggested. *The Journal of Aviation Medicine*, June, 1946, pages 253–256, 275, 4 illus.

The Incidence and Relation of Syncope to Decompression Sickness. Bruce R. Brown. The paper reports the incidence and analysis of syncopal reactions observed during a series of "chamber flights" carried out at 38,000 ft. for the purpose of studying the effects of well-controlled types of work on the incidence of high-altitude sickness, i.e., the occurrence of such symptoms as bends pain, "chokes," and abdominal gas pain. The analysis was carried out in a series of 100 individuals who took a total of 225 flights in a decompression chamber to a simulated altitude of 38,000 ft. and performed arm exercises at $2^1/_2$ min. intervals. The results of the investigation, which was carried out at the University of California, are summarized. *The Journal of Aviation Medicine*, June, 1946, pages 257–264.

Studies of the Effects of Morphine at Simulated High Altitudes and Its Use for the Relief of Pain of Decompression Sickness. Lt. Col. Paul K. Smith. In this investigation aviation students without previous denitrogenation were given doses of morphine, injected subcutaneously, and decompressed in a high-altitude chamber to a simulated level of 38,000 ft. It was found that the drug is effective in relieving decompression pain, but when given subcutaneously the onset of action is too slow to make it of practical use. The investigation was carried out at the A.A.F. School of Aviation Medicine, Randolph Field, Tex. *The Journal of Aviation Medicine*, June, 1946, pages 265–269, 4 illus.

Psychological Requirements in Aviation Equipment Design. Lt. Col. Paul M. Fitts. It is stated that if airplanes are to be operated with safety and effectiveness, they should be designed in relation to the psychologic capacities and limitations of fliers, as well as to their physiologic requirements. In the first section of the paper the writer proposes certain psychologic requirements for aviation equipment design. He points out, however, that before any of these requirements can be incorporated into the manufacture of equipment a great deal of specific research must be carried out.

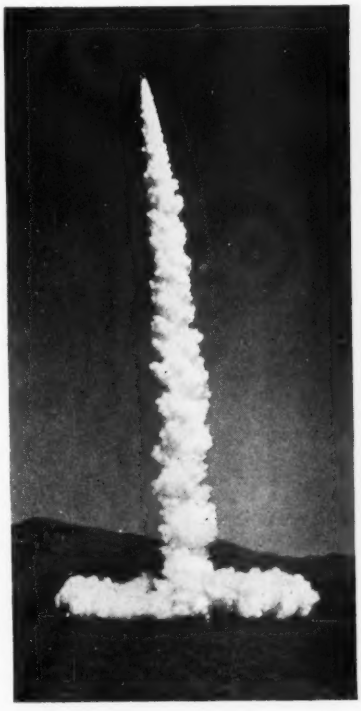
The second section of the paper contains an outline of a psychologic research program at the Aero Medical Laboratory at Wright Field. *The Journal of Aviation Medicine*, June, 1946, pages 270–275.

Meteorology

Physical Properties of the Atmosphere up to 100 KM. Results of recent calculations of temperature, pressure, density, and other physical measurements in the stratosphere up to an elevation of 100 km. are compiled and discussed. Assuming a homogeneous atmosphere, all major mechanical properties are expressed as functions of the temperature alone, and five fundamental equations for average air consisting of molecules of the gases are given. These equations are for calculating sound velocity, molecular velocity, pressure, density, and mean free path of molecules. Graphs illustrating some of the data accompany the article. *The Journal of Meteorology*, June, 1946, pages 27–30, 5 illus.

Wings Against the Storm. Lt. Harmon H. Harper. An account is given of a proposed scientific investigation of procedures for safe flying through thunderstorms, to be conducted at Pinecastle Army Air Base, Orlando, Fla., under the supervision of specialists from the Army Air Forces, the Navy, and civilian agencies.

Information secured is intended to form a basis for recommending instrumentation and flying procedures for radar- and nonradar-equipped aircraft so that hazardous conditions can be avoided; a means of determining where and under what conditions thunderstorms present a hazard to flying; establishing a method to determine or locate these flying hazards; formulating a description of a thunderstorm from a research standpoint by studying it throughout its life cycle. The equipment to be used, described in detail, includes P-61's equipped with special instruments; various types of air-borne and ground radar sets; and TG-52 gliders. *AAF Review*, August, 1946, pages 14–16, 48.



U.S. Army Air Forces Photo

A "GAPA" defense projectile being fired over the Utah salt flats. (See "'GAPA' Missiles," page 57.)

Only time will tell how great a slice of the world's transportation, both freight and passenger, will eventually be airborne. Much will depend on how well airlines will be able to compete with other forms of transportation. Truck and bus operators, for example, hope to speed schedules, improve payloads and cut costs through the use of engines built to take advantage of the extra available power in high antiknock gasoline. In the same way, improved aviation gasoline offers an opportunity for developing even more powerful and efficient aircraft engines which will help keep down operating costs.

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Military Aviation

'GAPA' Missiles. The Boeing Aircraft Company and the Air Matériel Command of the A.A.F. have engaged jointly in a supersonic guided-missile program that will develop pilotless aircraft capable of seeking out and destroying enemy aircraft or missiles. Details are still classified as confidential military information.

Named GAPA, for ground-to-air pilotless aircraft, these slim 10-ft. rockets are small pilotless aircraft that travel at supersonic speeds as "aerial destroyers." The first test models of the missile are propelled by standard Aerojet rocket units. In the models now being tested a booster power unit is attached to the tail of the pilotless aircraft, which accelerates the missile itself to supersonic speeds in a few seconds. Boeing Aircraft Company.

Parachutes

German Man-Dropping Container. The Technical Intelligence Division of the Air Matériel Command is studying a three-man dropping container that is 10 ft. long, weighs 490 lbs., and is intended to drop men from an airplane for sabotage or reconnaissance work. The passengers are strapped horizontally in harnesses but when the container is released from the plane it assumes an upright position with the men standing during the descent.

Four unconventional-type parachutes made of large triangular panels and having a diameter of approximately 48 ft. when deflated are employed in the design of the container. These operate independently to reduce oscillation and spill air to the center of the cluster because they have no openings at the apex. The container was first used in 1940 and, according to the Germans, it has such advantages as enabling men of special skills to be dropped without jumping experience, eliminating the separation which usually occurs in individual jumps, protecting the occupants from landing hazards, and reducing the chances of enemy detection. Two containers with an estimated weight of 1,500 lbs. could be carried beneath the wing of a light bomber. *Army Air Forces, Air Matériel Command.*

Photography

The Calibration of Air Cameras in Canada. R. H. Field. An account of the methods followed by the National Research Laboratories, Ottawa, in calibrating air cameras is presented. The simple setup used for finding the principal point location by autocollimation is described. Information is supplied about the apparatus employed for principal distance measurement, which also is relatively simple. *Photogrammetric Engineering*, June, 1946, pages 142–146, 3 illus.

Williamson O.S.C.-1 Air Camera. The Williamson O.S.C. Mark 1 photogrammetric air camera is described and illustrated. The all-electric operation of the camera is arranged in such a manner that the independent functioning of each unit is provided. The shutter, film wind, pressure plate, and instrument exposing switch are each separately powered units, electrically interlocked to ensure a correct functioning sequence. The camera body is of solid aluminum, providing the required degree of rigidity between the register glass and lens, which in turn are seated on parallel machined faces accurately spaced and tested for flatness and parallelism. The camera is operated by a remote control giving exposure intervals over a range of from 2 to 60 sec.

A hot-air system ensures operation in low temperatures. The camera operates within an air-heated enclosure with heat obtained from the normal cabin-heating supply. *Flight*, August 1, 1946, page 123, 1 illus.

Private Flying

Proving Personal Plane Efficiency Through per Mile Costs. Neil B. Berboth. An analysis is presented of the costs of owning and operating a personal airplane, and the possibilities for decreasing such costs. The writer offers a formula for estimating the direct operating costs on an annual and hourly basis with regard to fuel, maintenance, power required, utilization, passenger seats, cruising speeds, insurance rates, selling price, and depreciation. The text and tables deal with the cost components for personally owned airplanes and for charter and service operations. Other tables set forth the effect of weight, power, and quality on cost of manufacture of an airplane. Manufacturing costs and estimates of selling prices also are tabulated. Graphs show the effect of reduction of the various cost components on the total cost of manufacturing and operating a personal-type airplane. Means for reducing the prices of personal airplanes are discussed, as well as ways by which the operating expenses can be lowered. *The Pegasus*, August, 1946, pages 9–12, 1 illus.

Production, General

Production at Yeadon. A report of the production methods and wartime achievements of the camouflaged factory at Yeadon, England, operated by A. V. Roe & Company, Ltd., is accompanied by photographs of the plant.

Production figures and equipment details are supplied in a review of the plant's operations, which began in 1940. The aircraft referred to as products are the Anson, Avro Nineteen, Lincoln, York, and Lancaster. *The Aeroplane*, August 2, 1946, pages 127–129, 6 illus.

Production Methods

The Interpretation of Radiographs of Spot Welds in Alclad 24S-T and 75S-T Aluminum Alloys. Robert C. McMaster and Frederick C. Lindvall. The paper is one of a series that will deal with spot-weld radiography research conducted at the California Institute of Technology and the Battelle Memorial Institute during 1943 and 1944. In the introduction reference is made to the urgent need for a reliable nondestructive method of inspecting spot welds in aluminum alloys created by the vast increase in aircraft production during the war. Such a test was required particularly for spot welds in high-strength 24S-T and 75S-T aluminum-alloy sheets used in primary aircraft structures. It is noted that methods of interpreting weld strength and quality from radiographs have been developed rather completely for the case of two-layer equal-thickness combinations of Alclad sheets of high-strength aluminum alloys. The 24S-T and 75S-T aluminum alloys both contain a relatively large percentage of radiographically dense alloying constituent which makes it possible to obtain clear, high-contrast radiographic images. Welding defects indicated by these images are listed. Simple rules are given for the interpretation and evaluation of weld properties from spot-weld radiographs. *The Welding Journal*, August, 1946, pages 707–723, 30 illus.

The Welding of Non-Ferrous Metals. Part VII. E. G. West. Further information about the welding of magnesium alloys is presented in a continuation of Part VII of a serial article on nonferrous metal welding. The writer discusses helium and argon arc welding, the general details of procedure being identical for both processes. Consideration is given to the principles of the process, the gas supply, the preparation of the joints, setting-up operations, arc-welding procedure, and the properties of arc-welded joints. *Sheet Metal Industries*, August, 1946, pages 1584–1587, 7 illus.

Fluoroscopic Inspection of Steel. Gilbert C. Close. An outline is given of investigations carried out during the late war which resulted in establishing industrial fluoroscopy on a practical basis. The advantages and apparent disadvantages of fluoroscopic inspection are listed and compared with X-ray photograph inspection methods. A description is included of a new fluoroscopic unit installed at the Aircraft X-Ray Laboratories, Los Angeles, which is the result of wartime research work. The advantages of the machine are enumerated. Photographs of the viewing screen, made with the machine in operation and with different types of steel parts under inspection, are included. *Steel Processing*, August, 1946, pages 502–504, 5 illus.

Upsetting Tubular Members Simplified by Special Grippers. Lambert R. Pistoles. It is noted that the up-

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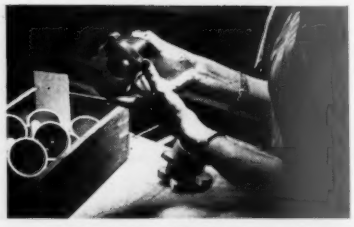

Zyglo inspection—a penetrative oil test—under black light reveals cracks or other surface imperfections present.

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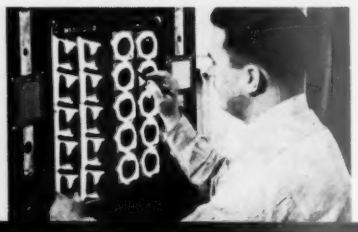

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setting of parts of tubular section with relatively thin walls, such as the shanks of aircraft steel propeller blades, presents an extremely difficult problem in avoiding collapse at the gripping area. The writer describes a method developed and used by the Curtiss-Wright Corporation which permits simultaneous upsetting of the inside diameter and the cuff ring with one stroke, displacing up to 45 cu.in. of metal. A special cooler designed to prevent the spread of heat from the upsetting to the gripping area also is discussed. *The Iron Age*, August 15, 1946, pages 42–48, 15 illus.

Machining Engine Valves. Part II. Further operations in the manufacture of valves for the Merlin engine at a plant of the Ford Motor Company, Ltd., are described. Information is given about the tooling of the five-spindle automatics for the remainder of the exhaust-valve operations and for the rather simpler inlet-valve sequences. *Aircraft Production*, August, 1946, pages 372–376, 11 illus.

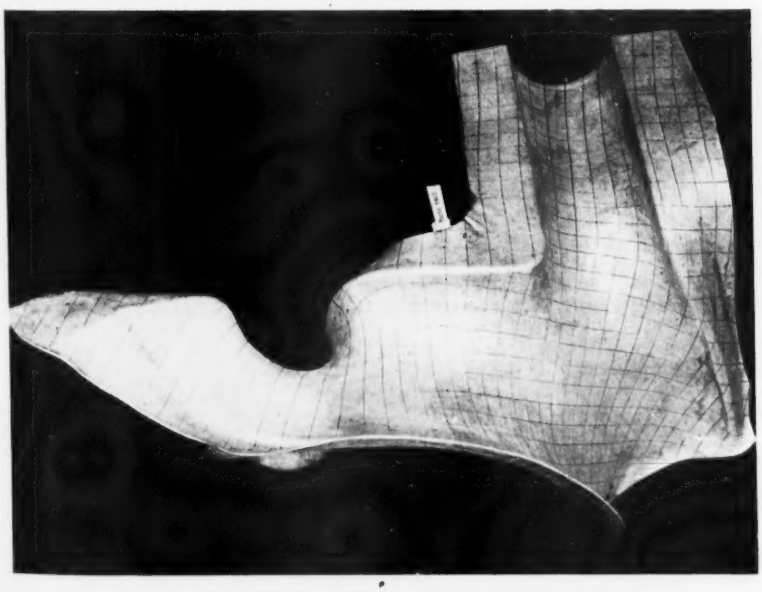
Low Cost Patterns for Multi-Stage Dies. R. Raymond Kay. The writer describes the technique of building patterns for dies for the short-run production of irregular-shaped parts by means of the Sol-A-Die process developed by the Solar Aircraft Company. During the war the process was applied to the manufacture of aircraft exhaust manifolds formed from 18–8 austenitic steel. The patterns are constructed of beeswax and cheesecloth, on the final pattern, and being flexible, may be bent to the desired form of the intermediate stages. The new process may be applied to the manufacture of Alclad parts for aircraft. Diagrams show five steps in making a pattern by the process. Four steps in the forming of an aircraft part in which production is low but accuracy and speed of production are essential are illustrated and described. *The Iron Age*, August 22, 1946, pages 56–58, 4 illus.

Design of Weldments for Best Results at Lower Costs. I. A. Oehler. It is explained how superior parts can be produced at a lower cost through the use of standard and special rolled shapes, proper shop equipment, and sound design techniques. Salient features of good welding design are set forth and their application in the design and fabrication of various parts is discussed. A welded aircraft-engine crankcase in which the finished weldment consists of a rolled channel section and forged diaphragm is described and illustrated. *Product Engineering*, August, 1946, pages 86–89, 6 illus.

The Spot Welding of Ten Aluminum Alloys in the 0.040-inch Gage. W. F. Hess, R. A. Wyant, and F. J. Winsor. A report is given of an investigation of the spot-welding characteristics of the newer aluminum alloys—R-301-T, XB75S-T (bare and Alclad), Alclad 24S-T81; and the older alloys—24S-T (bare and Alclad), 3S-$^1/_2$H, extruded 14S-T, 52S-$^1/_2$H, and 61S-T in the 0.040-in. gage. This is one of a series of reports on aircraft spot-welding research being conducted at the Rensselaer Polytechnic Institute. The ten alloys were studied with respect to their surface preparation for spot welding. With proper surface preparation and slight modification of welding conditions, good spot welds were readily obtained in the ten alloys. Limited laboratory experience indicated that with good surface preparation, better tip life can be obtained with the hard, bare alloys, such as 24S-T, XB75S-T, and 14S-T, than with the other materials having softer surfaces. It was found that in the clad materials sheet separation depends largely upon the thickness and hardness of the cladding. Because of this fact it was difficult to make sound welds without excessive sheet separation in the Alclad 24S-T81 which had abnormally thick cladding. Spot welds in 3S-$^1/_2$H, 52S-$^1/_2$H, and 61S-T exhibited higher ratios of strength in normal tension-to-shear strength than in Alclad 24S-T, Alclad XB75S-T, and R-301-T. It is stated that the effect of spot welds upon sheet efficiency is less injurious in the alloys that depend upon cold work for their properties than in the heat-treated alloys. *The Welding Journal*, August, 1946, pages 467-s–484-s, 34 illus.

Pressure Welding Thin Aluminum Parts. H. E. Linsley. The writer describes a German method of simultaneously welding and forming thin-walled aluminum parts. The article, which deals with two German plants utilizing this procedure, is a correlation of a report published in *Aircraft Production*, London, and a recent publication of the TIIC Aeronautics Subcommittee. It describes the use of pressure welding for fabricating aircraft radiator fins and similar hollow components. *The Iron Age*, August 8, 1946, pages 56–60, 9 illus.

An odd-shaped stainless steel part formed by the Sol-A-Die process, gridded to show that even in the final stage the grids are nearly square. (See "Low Cost Patterns. . . . ")



Production Tools and Equipment

Cemented Carbides Used for Other Purposes than Cutting Tools. K. R. Beardslee. A number of typical and economical cemented carbide applications of a noncutting-tool character are reviewed. One of these is the use of this material for deep-drawing dies. It is stated that carbon steel, stainless steel, and nonferrous metals are being deep-drawn in carbide dies that frequently have a life of from twenty to one hundred times that of comparable steel dies. To indicate the advantages obtained through the use of carbide drawing dies, the experience of a large producer of high-pressure gas cylinders is reviewed. It is further stated that in forming work carbide dies also have proved their value. The experience of a plant on the West Coast engaged in the manufacture of stainless-steel sleeves for airplane exhaust systems is reported. Various types of steel dies were tried but none produced more than from 500 to 1,000 pieces before reconditioning was required. Carbide dies regularly turn out between 5,000 and 10,000 sleeves to the required finish and tolerances before they need to be refinished. Consideration is given to the use of carbides for punches and dies, applications in the foundry, forge shop, and in various industries. *Machinery*, August, 1946, pages 150–156, 9 illus.

Optical Centering. S. C. Poulsen. The article describes an optical instrument developed during the war years at Handley Page, Ltd., for the drilling of photo-lofted sheets without the

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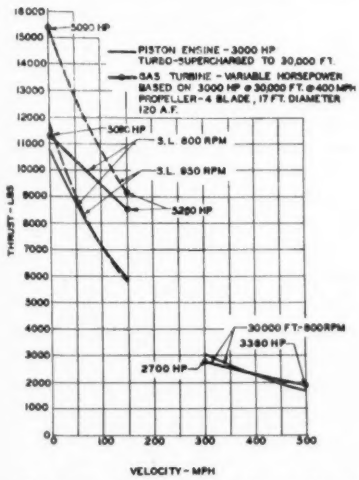
need for center-punching and similar protracted toolroom work. It is explained that after the company adopted photographic lofting methods the timesaving benefit was largely offset by delays caused by traditional workshop methods in the toolroom. As the toolroom threatened to become a "bottleneck," a more rapid method was sought by the use of which work could be transferred direct from photo-loft to machine shop. Investigations leading to the development and perfection of the method are described. Particulars are supplied about the results obtained. *Aircraft Production*, August, 1946, pages 359–361, 5 illus.

Sensory Torque Wrenches. In an item under the heading "Sensory Torque Wrenches" appearing on page 99 of the July issue of the AERONAUTICAL ENGINEERING REVIEW, a typographical error occurred with reference to the Model S2400-K Wrench of capacity 0–2400 in.lbs. This should have been designated as Model S2400-I. *P. A. Sturtevant Company*, Addison, Ill.

Propellers

Propellers for Aircraft Gas Turbines. George W. Brady. The major differences in characteristics of propellers for aircraft gas turbines as they affect propeller design are outlined and discussed. The higher powers that appear probable with the aircraft gas turbine make for airplane speeds in the range in which it has been predicted that good propeller efficiency could not be obtained, but it is shown that good propeller efficiency can be maintained up into the range of 600 to 700 m.p.h. The configuration of propellers for this type of application is discussed. Another characteristic of the gas turbine is that it is essentially a constant-speed power plant, which introduces new considerations in the design of propellers to give maximum efficiency at high speed and cruising and at take-off. Effect of diameter and solidity on this problem are considered and the advantages of two-speed reduction gearing are discussed. This paper considers single-rotation propellers primarily but dual-rotation types are examined briefly. A comparison of thrust and thrust horsepower for turbojet and turbine-propeller power plants is made and the results are applied to a fighter-type airplane. Special control characteristics of turbine propellers and weight and vibration problems are also discussed. *Journal of the Aeronautical Sciences*, September, 1946, pages 449–456, 468, 20 illus.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S.L. 800 RPM
S.L. 650 RPM
5280 HP
30000 FT - 800 RPM
3380 HP
2700 HP
THRUST - LBS
VELOCITY - MPH

Variation of thrust with airplane velocity for piston engine and gas turbine. (See "Propellers for Aircraft Gas Turbines.")

Variable-Pitch Airscrews. The general functions of variable-pitch propellers are described. An explanation of the aerodynamic principles involved introduces a discussion of the several types of variable-pitch propellers in existence and the advantages of counterrotating propellers. Specific propellers mentioned are the de Havilland units, Rotol, Ltd., products, and the American Curtiss electric propeller. *Modern Transport*, July 20, 1946, page 7, 1 illus.

Wake Studies of Eight Model Propellers. Elliot G. Reid. The influences of shank form and pitch distribution upon the characteristics of constant-speed propellers have been investigated by exploring the wakes of eight model propellers in the Guggenheim Aeronautical Laboratory of Stanford University. The experiments show that the improvement of efficiency which results from the substitution of faired shanks for round ones is caused by disproportionate local augmentations of thrust and torque. It is also found that blade-shank stalling at reduced advance ratios caused adverse effects which were amplified as the power coefficient increased. Analysis of previous force tests in the light of wake characteristics reveals that, for constant-speed operation, pitch should be so distributed that no element will operate at a negative lift coefficient in high-speed flight, that shank stalling during take-off and climb will be minimized, and that substantial uniformity of the section lift coefficients will prevail in normal cruising and high-speed flight. A blade-twist curve of the "envelope" type appears most suitable to these requirements.

In addition to the foregoing conclusions and the provision of a large mass of data for strip-method prediction of operating characteristics, the investigation led to the following noteworthy findings. The radial variation of section lift coefficient is in qualitative accord with that of the geometric angle of attack, and the average section lift coefficient at which maximum efficiency is attained increases with pitch. Abnormally large lift coefficients are attained by slightly cambered shank elements; this is ascribed to the action of a highly favorable radial pressure gradient upon their boundary layers. Finally, Glauert's prediction of the independence of blade elements is substantially confirmed insofar as twist is concerned, but his momentum-vortex theory is found unsatisfactory for the accurate prediction of propeller characteristics from airfoil-section data. *National Advisory Committee for Aeronautics, T.N. No. 1040*, July, 1946.

Radar

Radar. Edwin G. Schneider. A comprehensive study of radar includes a discussion of both air-borne and ground equipment. The general nature of electronic techniques is explained prior to the study of the subject of wave propagation and atmospheric effects. Other topics examined in detail and illustrated by graphs and photographs are the design of a basic radar set; modulator design; transmitter; radio-frequency techniques; receivers; antennas; indicators; radar systems; beacon and radar navigational systems, and radar aids to air navigation and traffic control. *Proceedings of the I.R.E. and Waves and Electrons*, August, 1946, pages 528–578, 86 illus.

Radio

Production of Ignition Radio Shields. F. T. Van Syckel. It is noted that the increasing use of radio in both private and commercial aircraft, as well as the probable future use of radar, places particular emphasis on the employment of radio shielding for the ignition systems of aircraft engines. Methods used by the Breeze Corporations in the production of ignition radio shields for aircraft are described. Silver-alloy brazing is used extensively. Particulars are given about the special jigs, fixtures, and gages employed. In principle, the ignition radio shield consists of a manifold, a tube of copper or brass of circular or square cross section, through which ignition cables are run, with outlets in the tube for spark plug and magneto connections. These manifolds are of varied design, depending upon the construction of the engine. Manufacturing operations and stages in the production of a typical manifold are described and illustrated. *The Iron Age*, August 29, 1946, pages 56–58, 5 illus.

Torsional Oscillating Motion with Self-Synchronized Impulse. David B. Nichinson. The article describes a new mechanical approach to the problem of maintaining an oscillation at a specific frequency and a variable amplitude in a resonant system. The principles discussed were incorporated in the design of a mechanical resonance scanner for air-borne radar systems as the result of an investigation of rapid scanning techniques. The principles and method can be applied advantageously to obtain a smooth rapid oscillation with a minimum of

power and power-transmitting parts. *Product Engineering*, August, 1946, pages 110–112, 7 illus.

Sperry Air Navigation Philosophy. Joseph Lyman. The development of radio aids to air navigation is traced briefly, showing that radio has now reached a stage where additional development and proper application can make possible economical air-line operations regardless of the weather factor. The writer outlines the contributions of the Sperry Gyroscope Company toward the improvement of navigational facilities and describes the Microwave Landing System and automatic flight control. *Sperryscope*, August, 1946, pages 19–21, 1 illus.

Research

AAF Plans for the Future. R. K. Winkelblack. Research and development work planned by the Army Air Forces is outlined. It is stated that this work will require the maintenance of the scientific and engineering groups of the aircraft industries as healthy going organizations and, in addition, adequate research facilities independent of experimental facilities, where specific problems connected with the design and construction of aircraft and missiles can be solved. The comprehensive program envisioned embraces all fields, including the following: (1) supersonic aircraft, piloted and pilotless; winged missiles having velocities approaching the meteoric; (2) nuclear energy applications for propulsion of aircraft and missiles, as well as for other atomic devices that may evolve in the future; (3) flight and survival equipment for use above the atmosphere, including space vehicles and devices for use therein; (4) aircraft and missile operating technique development, and the organizational structure. A development center with an area of 100 square miles and additional auxiliary fields and ranges are envisioned. Specifications of proposed facilities have been broken down into eight sections, namely, fluid dynamics, thermodynamics, physiology, flight engineering, structure and materials, electronics and wave phenomena, fuels and propellants, and instruments. Present and future projects are discussed. *Automotive and Aviation Industries*, August 1, 1946, pages 30, 31, 58, 60, 3 illus.

Rotating Wing Aircraft

Rotary Wing Development. James A. J. Bennett. Past development in rotating wing aircraft which has led to the successful building of helicopters is reviewed. It is noted that, although the consequences of the stall have been minimized by various artifices, below a certain translational speed the airplane is no longer a flying machine but becomes merely a falling mass subject to the law of gravity. The powered glider with rotating wings was the simple solution to an aircraft capable of taking-off and landing in a confined space, proposed by Juan de la Cierva and developed in this country and in England to a stage closely approaching the helicopter. By retaining nearly all the elements of the airplane and merely replacing the fixed wings with rotary wings, Cierva was able to isolate the behavior of the rotor system from stability and control problems. How the upward stream of air causes the rotor to rotate is illustrated diagrammatically. The use of a flapping hinge to equalize the lift moment is described. Other sections discuss gyroscopic and Coriolis effects, rotor-starting systems, direct control, direct take-off, and the powered rotor. Consideration then is given to helicopter configurations and their advantages and limitations. *The American Helicopter Quarterly*, January, 1946, pages 11–24, 13 illus.

Drive Systems for Helicopters. Walter H. Pearson. In a paper on drive systems for helicopters, a comparison is made between automotive and helicopter power-transmission requirements. It is stated that the safety features of the helicopter depend upon the ability of the drive and rotor system to provide safe descent in the case of engine failure. Ascent, hovering, and even cruising impose much higher loads than are encountered in the average motor car. Load ratings for the helicopter drive

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system are considered to be approximately 80 per cent of engine power for 90 per cent of the time. The automobile engine operates on less than 25 per cent load for 90 per cent of the time. For a 100-hp. engine, resulting in 25 hp. utilized, the helicopter would be using about 80 hp. This difference in loading is important to the aircraft designer from the standpoint of weight.

The factors affecting weight per horsepower of a helicopter transmission are outlined. For a small helicopter, the weight of the transmission is stated to be 0.3 lb. per hp.; for single-rotor helicopters of the 450-hp. class the average is placed at 0.9 lb. per hp. For aircraft of no greater power, but requiring two rotors and a long transmission mechanism, the weight per hp. is approximately 1½ lbs. The relative merits of different metals used in the construction of transmission components are discussed with regard to thermal expansion, corrosion, and softness. The writer feels that spiral bevel gears are the most practical inasmuch as that type lessens the problem of planet-carrier and planet-shaft deflection. A detailed description of the problems overcome by this type of gearing is presented. Clutches, bearings, lubrication, and testing are considered. *Aero Digest*, August, 1946, pages 70, 71, 100, 2 illus.

Approach to the Vibration Problem. J. P. Perry. The article describes work carried out in 1943 by G & A Aircraft, Inc., a subsidiary of The Firestone Tire & Rubber Company, which was directed toward the development for the Air Matériel Command of a small liaison helicopter that would have improved qualitative performance. Particular emphasis was to be placed on the development of an aircraft that would show broad basic improvement in rotor-induced vibrational characteristics including the objectionable so-called "stick-shake." A close scrutiny and analysis of rotor-blade theoretic operation on both helicopters and autogiros failed to disclose differences of sufficient magnitude to explain the helicopter's then poor performance in this respect. A detailed comparison between existing helicopters and the qualitatively satisfactory direct-control autogiros was made. The more important findings from this study indicated an apparently wide disagreement in the following: rotor-blade torsional rigidity; rotor-blade construction, especially with reference to maintenance of airfoil contour; rotor-blade damping means. Research work that led to the development of the XR-9B helicopter with fixed rotor head is described. *American Helicopter*, August, 1946, pages 29, 40, 2 illus.

Practical Engineering of Rotary Wing Aircraft. Part II. Paul H. Stanley. Continuing an extensive discussion of rotating-wing aircraft design problems, the writer presents two further analyses. The first constitutes a study of the application of jet-drive to the blades of a direct-control autogiro. The second consists of an examination of load developments in the blades of a jet-driven helicopter or in autogiro blades with jet-assisted take-off and landing features. *Aviation*, August, 1946, pages 76–82, 14 illus.

Helicopter Problems. Stan J. Burwell. A review of the helicopters in existence at present and the early development of both helicopters and autogiros. Flight characteristics of both types are described. Both single- and twin-rotor helicopters are analyzed. Control and operation for the accomplishment of various fundamental flight maneuvers are explained. A comparison of existing helicopters is given in the text and is listed in a table which supplies specifications for 16 rotating wing aircraft. The various centers of helicopter research are referred to and a series of events in helicopter development is listed chronologically. *Canadian Aviation*, August, 1946, pages 50, 52, 54, 66, 68, 70, 10 illus.

Helicopter Outlook in the Navy. Rear Adm. H. B. Sallada. The future of the helicopter in naval aviation is considered. It is observed that the limitations of early helicopter models in power and performance led the Navy to investigate possibilities of larger load-carrying types, with a view toward increasing the functional utility of helicopters in performing more extensive operations. Two major developments have been carried on by the Bureau of Aeronautics since early 1944 in two large twin-rotor helicopters—the Model XHRP-1 (Piasecki Helicopter Corporation) and the Model XHJD-1 (McDonnell Aircraft Corporation). Both have normal useful loads of greater than 2,500 lbs. and have demonstrated the greater load-carrying abilities possible in larger helicopters. It is stated that the knowledge gained in the development of the XHRP-1 tandem helicopter will prove useful in similar developments of both larger and smaller aircraft of this type, and that a greater insight into the problems of helicopter design will result from an extensive program of flight research scheduled for the XHJD-1. Variations of rotor diameter, blade chord, rotor-engine gear ratio, gross weight, and control sensitivity are possible on this helicopter which will be tested under every conceivable arrangement. Consideration is given to the possibility of using helicopters to perform miscellaneous tasks that have been performed by the destroyers of a task force. *American Helicopter*, August, 1946, pages 11, 42, 2 illus.

New Horizon for the Helicopter. Malcolm G. Davis. Summarizing the results of studies relating to the potential uses of the helicopter, the writer states his opinion that in the field of commercial transportation direct-lift aircraft may be expected to find an extensive market in (1) supplementing trunk-line air-transport operations by providing airport shuttle services in the major metropolitan areas; (2) short-haul transportation between groups of cities having extensive commercial and industrial interests and located within maximum route distances of approximately 100 miles; and (3) for various types of passenger charter. Unit operating costs per flight-mile for hypothetic helicopter air-transportation operations are estimated. *Air Transportation*, July, 1946, pages 18–23, 2 illus.

The Lemont Helicopter. The Lemont helicopter, incorporating simplified design and low cost as the primary features, is briefly analyzed. The aircraft, for which the inventor has planned both one- and two-passenger types, is designed to weigh 350 lbs. and to carry 400 lbs. of useful load. Specifications call for a 75-hp. Continental engine, a top speed of 100 m.p.h. and a maximum rate of climb of 1,200 ft. per min. A feature of the design is simplified control using only a single wheel on a stick. *Yankee Pilot*, August, 1946, page 15, 2 illus.

Variants of the Helicopter. J. A. J. Bennett. Three variants of the helicopter are described as (1) the convertible jet-propelled helicopter, in which the rotor blades are driven without torque reaction by auxiliary blade-tip jets in vertical flight, but are normally autorotative as the autogiro, the total power in forward flight being supplied to a forward propeller; (2) the "gyrodyne," which, as its name indicates, has a powered rotor for sustentation and vertical climb, but also has a forward propeller for propulsion. A variable proportion of the total power is supplied to the rotor in forward flight and the remainder to the propeller; (3) the conventional helicopter, which has no forward propeller, all the power being supplied to the rotor or rotors. The performance of the three types in vertical and translational flight is discussed and various design considerations are set forth. The advantages of the low-pitch helicopter are described. *American Helicopter*, August, 1946, pages 8–10, 36, 6 illus.

McDonnell, Navy Unveil First Twin-Engine Helicopter to Fly. Brief specifications are given about the XHJD-1 twin-engined helicopter, produced by the McDonnell Aircraft Corporation for the Navy, now being flight tested. It is designed to cruise at more than 100 m.p.h. carrying a useful load of over 3,000 lbs. Powered by two 450-hp. Pratt & Whitney Wasp Jr. engines, the XHJD-1 has twin rotors of 40-ft. diameter attached to the fuselage on either side by long pylons, which carry the engine nacelles midway. The aircraft will fly on either of the two engines, since either engine will drive both rotors through a system of overrunning clutches. The twin-rotor system elim-

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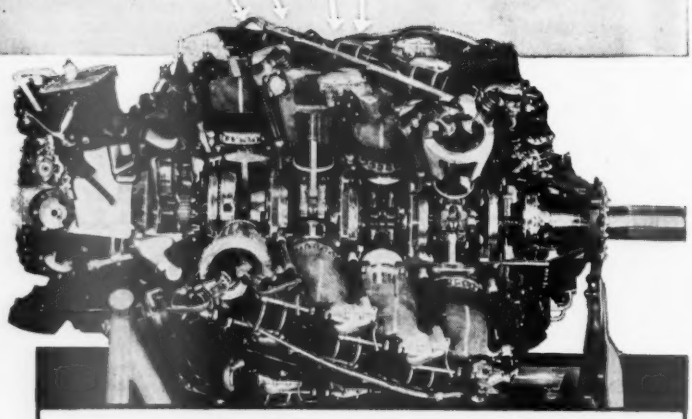

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inates need for an antitorque rotor at the tail, since the large rotors rotate in opposite directions. *Aviation News*, September 2, 1946, pages 9, 11.

History of Rotary Wing in the United States. R. G. Anderson. The evolution of rotating wing aircraft in the United States is reviewed. The writer traces developments in the design of rotors and controls from the year 1929 when the Autogiro Company of America was formed. Various design problems and their solutions are discussed. One section is concerned with the development of military autogiros. *The American Helicopter Quarterly*, January, 1946, pages 26–40, 16 illus.

"Roteron" XM-1 Helicopter. A description is supplied of the single-place helicopter, the Roteron. The first model, the XM-1, has a five-cylinder, radial-rotary, four-cycle air-cooled Noble engine, placed between the upper and lower rotor assemblies. The engine case is attached to the lower rotor hub, while the shaft of the engine is attached through a 2:1 planetary reduction gear to the upper rotor. A stationary carburetor is located directly beneath the bearing housing and fuel is drawn up through the revolving shaft. Electrical energy for ignition is supplied through slip rings. Each of the coaxial rotors has three blades, the lower one having a much larger diameter than the upper one.

The construction and operation of the craft, its rotors, and controls are described. Dimensions given are as follows: weight empty, dry, 230 lbs.; gross weight, 400 lbs.; maximum rotor span, 15 ft. 6 in.; overall length, 19 ft. 2 in.; overall height, 6 ft.; body width, 28 in.; and landing gear tread, 8 ft. 4 in. The distance between rotors is $18\frac{3}{4}$ in. Aerodynamic problems involved in the rotor design are mentioned. *Aero Digest*, August, 1946, page 86, 1 illus.

German Submarine Rotary Kite. An unconventional-type aircraft, resembling a combination kite and helicopter and used by the Germans in air observation from submarines, is being studied and tested by Technical Intelligence, Air Matériel Command, at Wright Field. The craft, named the German Submarine Rotary Kite by Intelligence and called "Sandpiper" by the Germans, weighs only 180 lbs. and does not have an engine. It is towed by a submarine and thus gains its ability to remain in flight. The kite consists of a pilot seat, pylon, conventional autogiro head rotor, a horizontal supporting tube extending aft, and a rudder operated by the pilot's seat. The landing gear consists of skids which can be folded parallelogram fashion. It can be disassembled to make a compact package and stored in a submarine. Helicopter pilots find it easy to fly, and it is believed that several crew members on each submarine were capable of operating this aircraft. Launched with a slight backward tilt, the kite is towed on a cable 200 to 500 ft. long. The fastening point is slightly ahead of and below the center of gravity. Since the force exerted by the 24-ft. rotor obviously can exceed the gross weight, it has a stop that limits possible backward tilt of the rotor to avoid overloading.

The rotor blades are similar in construction to those of British and United States manufacture. They are untapered in plan or thickness, and are covered with fabric. For spar attachment at the vertical hinge, a shouldered sleeve is brazed to the inboard end of the spar. Controls are the conventional stick and rudder pedals. The longitudinal system has push-pull tubes and bell cranks throughout. The lateral and rudder controls are cable-operated.

The body structure consists of two main members, one horizontal and the other vertical. Upon the horizontal member is mounted the seat, controls, and landing skids at the forward end, and the tail surfaces at the rear end. The vertical part is the pylon for the rotor and is attached to the horizontal member near the seat. Both members are steel tubes, as are all the small members serving as supports for the seat, controls, and landing skids.

Specifications are as follows: rotor diameter, 24 ft.; empty weight, 180 lbs.; disc loading with 150-lb. pilot, 73 lbs. per sq.ft.; solidity, 0.0795; chord, 12 in.; twist, 4° reducing at tip. *Army Air Forces, Air Matériel Command.*

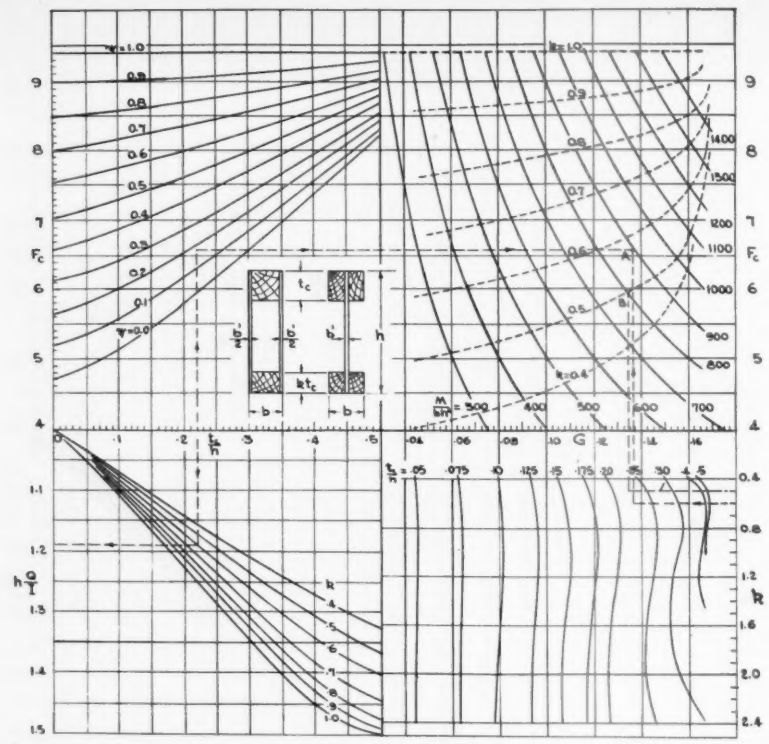
A closeup view of the Firestone Model 45 helicopter. A small antitorque tail rotor is mounted at the end of the boom shown at the right center of the photograph. (See "Firestone Helicopter.")

Firestone Helicopter. The new Firestone Model 45 helicopter is a commercial version of the A.A.F. XR-9B which was built by G & A Aircraft, Inc., subsidiary of The Firestone Tire & Rubber Company. It is powered by a 125-hp. four-cylinder engine, driving a 30-ft. diameter, three-blade main rotor and a small antitorque tail rotor. Overall height is 8 ft. 1 in.; length is 25 ft. 5 in. The craft is equipped with dual controls and side-by-side seating arrangement in a Lucite-enclosed cabin that provides a 270° range of vision. It weighs less than half as much as a low-priced automobile. Results of flight tests of the two-passenger "coupe" model will influence the design of a four-place family type of helicopter "sedan" now being developed. *The Firestone Tire & Rubber Company.*

Stress Analysis and Structures

Flight-Test Investigation of the Strength of a Square-Tipped Wing. Leonid A. Minor. Loads measured in the outer portion of a square-tipped wing during flight differ substantially from the design loads calculated according to ANC-1 specifications. A rapid increase of loads per g at the tip is observed at certain speeds and accelerations because of stall or compressibility effects. In bending, the critical wing section shifts from the tip, at high altitude where the stall and buffet boundaries can be attained to the root, at low altitudes where, in general, the operating restrictions limit the normal accelerations well below these boundaries.

Test data are presented and analyzed, and conclusions are drawn relative to the strength that is required



Design chart for spruce spars. $\psi = b'/b$. F_c = compression modulus of rupture—lbs. per sq.in. ÷ 1,000. (See "Chart for the Design of Wooden Spars. . . . ")

at different wing stations in order to avoid critical failures if design limit accelerations are exceeded in flight. *Journal of the Aeronautical Sciences*, September, 1946, pages 469–474, 8 illus.

Chart for the Design of Wooden Spars. Bernard Etkin. One of the problems of aircraft design involving repetitious and time-consuming computations is the trial-and-error selection of structural sections, as exemplified in the design of built-up spars for wooden aircraft. To assist in this case, a chart is presented by means of which allowable bending moments can be rapidly determined for spar sections of the types commonly used. To aid in shear strength calculations, values of the ratio of moment of inertia and moment of area also are given. A section "efficiency" is defined on the basis of resistance to bending, and some typical graphs of this quantity are given. *Journal of the Aeronautical Sciences*, September, 1946, pages 498–500, 3 illus.

The Calculation of Frequencies of Vibration of a Truncated Cone. H. D. Conway. This paper has been written as a sequel to a paper by Dr. J. F. C. Conn titled "Vibration of a Truncated Wedge," which was published in the April, 1944, issue of *Aircraft Engineering*. The three modes of vibration—longitudinal, flexural, and torsional—of a truncated cone encastré at one end and free at the other are considered separately. Special attention is given to the vibration frequencies of the cone and uniform cylinder. *Aircraft Engineering*, July, 1946, pages 235, 236, 1 illus.

Simplified Statics. R. Hadekel. Graphical and kinematic methods of solving problems of statics are presented. An actual problem in landing-gear work is used as an illustration. The writer shows how certain cases can be easily solved by simple principles of kinematics. *Aircraft Engineering*, August, 1946, pages 264, 265, 4 illus.

The Electrical Measurement of Strain. S. C. Redshaw. It is noted that the electrical measurement of strain includes the electrical magnification and measurement of a strain indicated by a nonelectrical pickup, such as a mechanical strain gage, as well as the case of pure electrical measurement in which the pickup unit itself operates electrically. Reasons for the popularity of electrical gages are mentioned. Before discussing measuring systems that incorporate pickup units operating on electrical principles, the writer briefly reviews two of the more important quasi-electric types, which have been widely used, namely, the acoustic strain gage and the Piezo-electric crystal strain gage.

Consideration then is given to variable-capacitance and variable-resistance strain gages. In the remainder of the paper, some principles concerned with the use of wire resistance gages are discussed. Sections are devoted to factors influencing the selection of the wire for the gage; methods of gage manufacture; the attachment of the gage to the specimen; thermoelectric effects in the wire system; strain gage circuits; and the calibration of the gages. *The Journal of The Royal Aeronautical Society*, August, 1946, pages 568–612, 29 illus.

A Buckling Problem. J. Ratzersdorfer. An analysis is made of the buckling conditions for a beam resting on a continuous elastic foundation with concentrated elastic end supports. Consideration also is given to the case where there are many equally spaced elastic supports of equal rigidity. It is shown that the results obtained for the first case can, under certain conditions, be applied to the second case as a close approximation. *Aircraft Engineering*, August, 1946, pages 266–268, 4 illus.

Residual Stresses Can Be Beneficial or Might Cause Failure of Part. J. O. Almen. It is shown that residual stresses in machine parts, such as bolts and springs, may be an asset or a liability, depending on their relation to the stress pattern of the working load. Examples of the results of tests and investigations of failures of parts in service illustrate the degree to which ordinary manufacturing operations and processes can reduce the expected load-carrying capacities of machine elements in simple tension when the effects of the processing operations are not taken into account. Charts that show how stress raisers and stress corrosion affect the life of parts, and curves that relate the life of parts to human life expectancy are included. *Product Engineering*, August, 1946, pages 81–85, 10 illus.

Graphical Method of Determining the Deflexion of Laterally Loaded Struts. N. A. Townsend. It is noted that the solution of the differential equations for the varied cases of laterally loaded struts presents arithmetical difficulties, particularly as the number of the integration constants contained in a problem increases. The time taken to obtain an acceptable solution can be extremely long if the first answer arrived at does not seem to be of the right order, thereby indicating an error in the evaluation of the constants. It is pointed out that a graphical method, besides giving the shape of the deflection curve and value at any position along the strut, is more satisfactory since any error in shape is immediately noticeable. The bending-moment diagram, an integral part of the method, is also available so that the final solution of the problem presents the bending moment and deflection at any point along the strut. The graphical method consists of drawing the polar diagram for the particular case of laterally loaded strut and constructing the bending-moment diagram from it. To illustrate the method, a fully worked example is presented. *Aircraft Engineering*, August, 1946, pages 269, 270, 5 illus.

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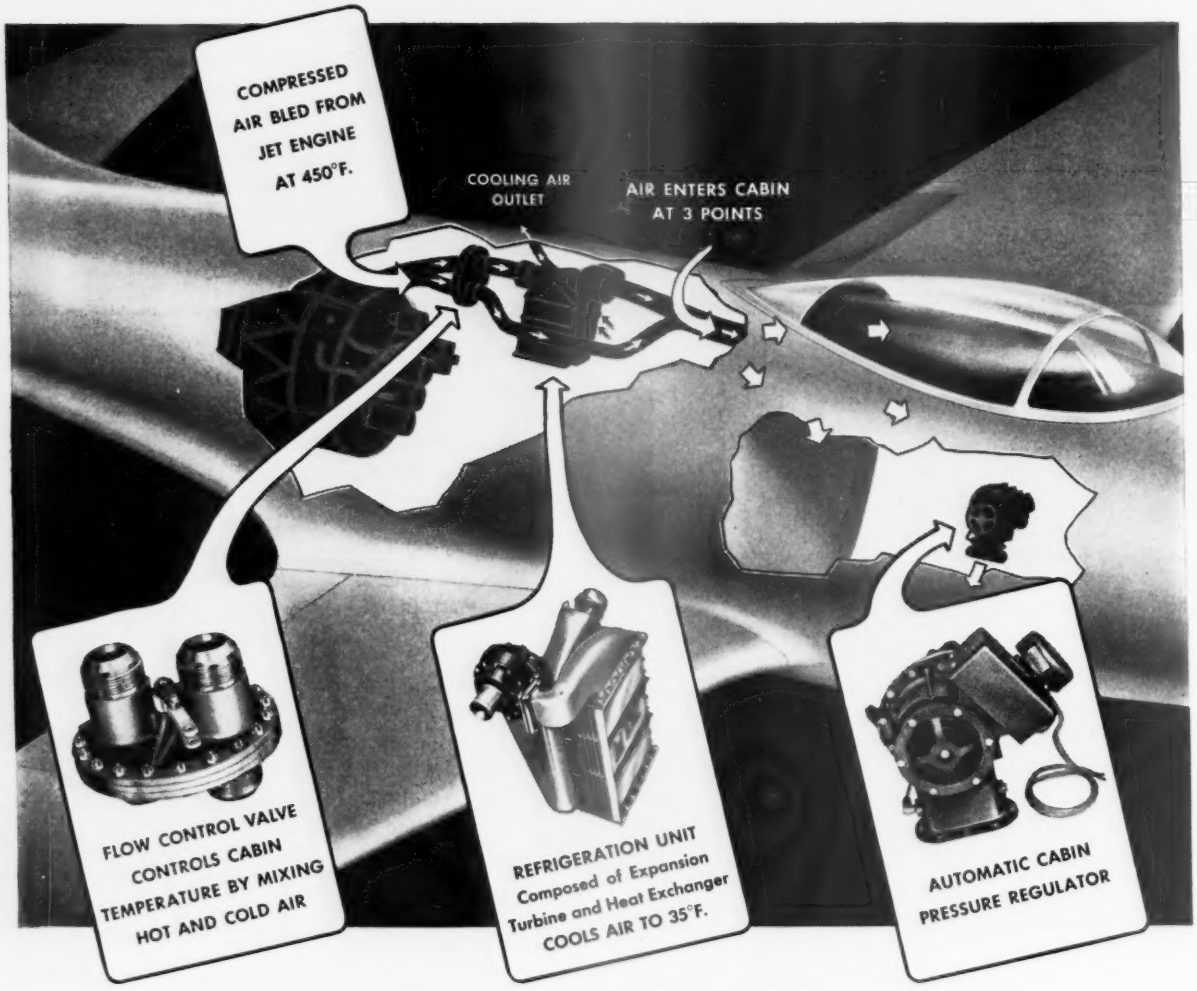
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Continental Finds Stresscoat Analysis Valuable Guide in Redesigning Engine Parts. Joseph Geschelin. A description is given of how the Continental Aviation and Engineering Corporation is using the experimental stress analysis technique developed by the Stresscoat Division of the Magnaflux Corporation for qualitative design analysis. It is explained that the method embodies refinements that stem from exhaustive work conducted by the Cleveland laboratories of the Aluminum Company of America. In this method the test specimen is coated with a brittle lacquer which cracks as the part is strained during the static test. After the location of stress concentrations in the engine part has been established, the actual loading is calculated from strain-gage and extensometer readings taken under actual flight conditions. It is stated that Continental's experience has shown that the usual conception of product design fails to satisfy the requirements of lightweight, highly stressed elements.

In many cases ribs and stiffeners induce stress concentration, that is, are stress intensifiers instead of strengthening members. In many instances stress analysis points to a pattern of better utilization of material—a redistribution of metal—which actually reduces the total weight of the part and gives the lighter part greater durability. Examples are included of the ways in which stronger and lighter parts have been developed as a result of the new stress-analysis techniques. *Automotive and Aviation Industries*, August 15, 1946, pages 36–39, 100, 8 illus.

The Problem of Landing Shock. J. Lockwood Taylor. A consideration of how aircraft structure stresses in landing are modified by dynamic effects. It is pointed out that sudden loading of a simply stressed member in tension, compression, or shear can cause stresses of twice the static value, and that there is need of investigation as to the adequacy of the normal type of strength calculations carried out on a static basis. The response of the structure of variable loading is discussed, and some numerical results are quoted for a case that has been calculated in detail. *Aircraft Engineering*, August, 1946, page 270.

The Expanding Domain of Aeroelasticity. A. R. Collar. By means of a broad survey of the developments in aeroelastic science during the past 10 years and of comparable developments in associated fields, insofar as they involve elastic deformation, the writer attempts to show how the individual subjects concerned are developing strong interconnections. It is explained that at one time the subjects were for the most part regarded as discrete entities but now are developing into component parts of an integrated whole—the dynamics of a deformable airplane. It is suggested that in the future it may be necessary to discontinue the present methods of treatment of the component subjects as separate, and to adopt a standard method of attack on the problem treated as a unified whole, especially when adequate computational aids become available. A modified approach, involving an arrangement of the subjects in a frequency spectrum, also is discussed. Some speculations on the elastic provisions that may be necessary in the future are included. *The Journal of The Royal Aeronautical Society*, August, 1946, pages 613–636, 3 illus.

Stresscoat pattern in a well-designed crankshaft statically loaded in torsion. Note the excellent stress distribution and blending of torsional stress lines on the journal with the stress lines on the web. (See "Continental Finds Stresscoat Analysis Invaluable. . . . ")

The Analysis of Plane Braced Frames. R. J. Cornish. The article presents an extension of a method for determining secondary stresses in members of varying cross section which was published in the February, 1944, issue of *Aircraft Engineering*. It deals only with those properties used in the moment balance method of secondary determination. The properties investigated are stiffness, the carry-over factor, and change of length under aerial loading. *Aircraft Engineering*, July, 1946, pages 231–233, 236, 11 illus.

Stress Diffusion Problems. Parts II and III. W. J. Goodey. Problems of stress diffusion in air frames are further discussed in the second and third installments of a serial article. In the second installment, various accurate solutions of the problem of the reinforced panel are investigated by using the stress-function. It is then possible to form an idea of the accuracy of the "stringer-sheet" solution and of the conditions that must be satisfied in order that it may be reasonably accurate for practical purposes.

Sections are devoted to the stress-function solutions for end load in a reinforced panel; and the diffusion of bending in a flat panel. The third installment deals with the diffusion of bending moment into a panel, taking into account the bending stiffness of the flanges. *Aircraft Engineering*, July, 1946, pages 227–230, 234, 2 illus.; August, 1946, pages 271–276, 4 illus.

Effect of Normal Pressure on Strength of Axially Loaded Sheet-Stringer Panels. A. E. McPherson, Samuel Levy, and George Zibritosky. Tests under combined axial load and normal pressure were made on twenty-nine 24S-T aluminum-alloy sheet-stringer panels. The panels had lengths of 12 and 19 in., widths of $16^3/_4$ and $24^3/_4$ in., and sheet thicknesses of 0.025 and 0.051 in. They were reinforced by extruded "Z" stringers spaced 4 in. between centers. The normal load on the sheet side of the panel was varied from 8 lbs. per sq.in. of vacuum to 16 lbs. per sq.in. of pressure.

Empirical formulas were derived for predicting the effect of normal pressure on the strain for buckling of sheet between stringers. The observed buckling strains were compared with theoretic values obtained in *N.A.C.A. T.N. No. 949*. The axial load carried by the sheet was measured for all the panels. The measured axial load was compared with the theoretic axial load for sheet without normal load as given by Marguerre.

The maximum load and the mode of failure were observed for all the panels. The measured loads were compared with values obtained from the nomogram in *N.A.C.A. T.N. No. 856* for flat panels of the same design without normal pressure. A simple formula was fitted to the data to describe the reduction of maximum axial load due to the presence of normal pressure. *National Advisory Committee for Aeronautics, T.N. No. 1041*, July, 1946.

Wind Tunnels and Laboratories

Electric Equipment for Cornell Variable Density Wind Tunnel. C. C. Clymer and M. A. de Ferranti. The variable-density wind tunnel at the Cornell Aeronautical Laboratory is described from the point of view of the electrical engineer, and the principles governing the selection of electrical equipment for wind tunnels are discussed. An outline is given of the aerodynamic principles determining the power requirements of the tunnel.

Particulars are supplied about the selection of the main propeller drive and the power-supply system. Other sections are devoted to power-model testing and model-motor calibration. *Electrical Engineering*, August-September, 1946, pages 554–563 (Transactions), 13 illus.

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Books

Fifty Years of Flying

Griffith Brewer

Mr. Brewer's first balloon ascent was made on May 9, 1891, and the latest flight recorded in this book is his passage from Newfoundland to England in a Liberator bomber in June, 1941. The freshness and enjoyment evident in his story of both flights are characteristic of his account of the intervening fifty years. The first half of the book is concerned with ballooning experiences. The author's thorough knowledge of the theory of ballooning has been useful to the Allied cause in two world wars. His book of lectures on the subject reached its eleventh edition in 1940.

The airplane experiences comprising the second half of the book are especially interesting because of the author's long and close friendship with the Wright family. It began with his flight with Wilbur Wright in 1908. He learned to fly at the Wright school in Dayton in 1914. He organized and collected funds for the establishment of the Wilbur Wright Memorial Lectures of The Royal Aeronautical Society in 1912, and delivered the fourth lecture, in 1916, on the life and work of Wilbur Wright. His description of the Wright Brothers' wind tunnel and their work leading up to the flights of 1903 is in many ways the best available, and the same is true of his pioneering analysis of the Hammondsport trials of the Langley machine. In this book this material is reprinted to some extent, but with more personal background.

Not many men have duplicated the accomplishments of the author, who studied ballooning thoroughly, later took up flying, then after several years renewed his flying on newer airplanes at the age of 62, and qualified as an autogiro pilot at 63. Mr. Brewer is probably the only man to be advised by Orville Wright to stop looping at the age of 68. He took this advice, especially when he remembered that on two occasions he had forgotten to fasten his safety belt before looping.

Lord Brabazon of Tara in his foreword commends this book to all who are interested in flight and the truth in connection with it. The book is written with a personal touch that sheds new light even when the topic is familiar, and contains much that has not been readily available about early ballooning and airplane history. The firsthand accounts of Atlantic crossings by airship and bomber, a tour by airplane of Nazi strongholds in 1937, a flying-boat trip to the Nile in 1937, and the winning of the Gordon Bennett balloon race in 1908 show some of the varieties of aeronautical experience possible to an active man who, however modestly, now tells also something about himself. Air League of the British Empire, London, 1946; 170 pages, 10*s.* 6*d.*

The Aviation Mechanic's Engine Manual

John W. Vale, Jr.

This manual is intended for school use and for use in preparation for a C.A.A. mechanic's rating. The text of many of the chapters is almost entirely in the form of questions and detailed answers. This form of exposition is used in combination with clearly written text and good drawings and photographs to make an excellent textbook and source of reference for the inspection and maintenance of engines, engine accessories, and propellers. There is included a chapter on AN parts, a glossary, and a list of films and film strips, correlated with the chapters of the book. Brief appendixes on jet propulsion and atomic-power engines are also included. McGraw-Hill Book Company, Inc., New York, 1946; 757 pages, $5.00.

Aeronautical Navigation

Charles A. Zweng

A manual prepared for pilots as a text on aerial navigation is intended also for ground instructors and teachers in schools and colleges that have aeronautical courses in navigation. The subjects included are pilotage, dead reckoning, and radio navigation. Theory as well as practical problems are examined in detail. Forty-two pages of questions and answers outline the material presented in the text. Pan American Navigation Service, North Hollywood, Calif., 1946; 198 pages, $3.00.

The Saturday Evening Post Aviation Survey

The major results of a comprehensive survey of the aviation industry conducted by the *Saturday Evening Post* are given in condensed form in a large ring-bound book, illustrated by many charts and graphs. The purpose of the survey was to obtain information regarding (1) public opinion on national policy questions pertaining to military and commercial aviation; (2) the attitude of the public toward travel by air; (3) the attitude of the public toward owning and operating private airplanes.

The report gives the results, thoroughly analyzed and tabulated, of personal interviews with 8,088 men and women. The questions dealt with the military phases of aviation from the standpoint of the future defense of the nation, as well as the commercial possibilities of aviation, from a national as well as individual point of view.

The survey is divided into three principal parts, classified according to the information sought, as listed above. The Curtis Publishing Company, Philadelphia, 1946; 65 pages.

Book Notes

Beams on Elastic Foundation, by M. Hetenyi; University of Michigan Press, Ann Arbor, Mich., 1946; 255 pages, $4.50.

The author presents a comprehensive mathematical analysis of the elastically supported beam, including both the instances in which the identity of the beam and that of the foundation can easily be established, and those in which the concept of beam and foundation is of a more abstract nature. Because it was found that previous studies of the subject had left unanswered many questions of interest to engineers, it was necessary to develop new solutions and work out new cases of loading. The book constitutes Volume XVI of the Scientific Series of the University of Michigan Studies.

Variable-Pitch Propellers, by J. A. Kyd; Sir Isaac Pitman & Sons, Ltd., London, 1945; 76 pages, 6*s.*

A detailed description of British variable-pitch propellers is presented as an aid to pilots, ground engineers, mechanics, and technical employees in aircraft factories. Chapters deal with the development of the variable-pitch propeller, its operation on the ground and in flight, the de Havilland hydromatic propeller and governor unit, the Rotol external cylinder propeller and governor unit, and the Rotol electric propeller and governor unit. A glossary of propeller terms is included.

World War II: A Concise History, by Roger W. Shugg and Major H. A. DeWeerd; The Infantry Journal, Washington, D.C., 1946; 538 pages, $3.00.

A new edition is offered of the history previously published as *The War in Outline* and as *The World at War*, which was used in various editions in the War Department orientation program. The new edition contains additions and changes and ends with the Japanese surrender on the U.S.S. "Missouri." There are 44 maps, 14 appendixes of texts of documents and statistics, and a good index.

Brassey's Naval Annual, 1945, edited by Rear Adm. H. G. Thursfield; The Macmillan Company, New York, 1945; 450 pages, $6.00.

In the first chapter of the 56th issue of this authoritative annual, the editor discusses the organization of fighting forces and he concludes that one force formed of land, sea, and air forces is not practical or necessary, in view of the successful cooperative operation of both the British and American forces during the war. The air war at sea during 1944 is reviewed by Major Oliver Stewart; the strategy of the Pacific war by Lt. Bernard Brodie, U.S.N.R.; sea-air-land power in the Pacific by Air Commodore L. McLean; and a chapter on carrier operations is signed "Volage." A naval chronicle of the year 1944, foreign navies, the future of British maritime industries, the landing in Normandy, and the Navy after the war are the subjects of other chapters. The usual reference section of ship and aircraft data and the pictorial section conclude the book.

Meteorology for All, by Irving Kohn; Barnes & Noble, Inc., New York, 1946; 162 pages, $1.00.

A handbook on meteorology discusses informally the physical components of the atmosphere, the forces acting on air masses and their resultant characteristics and geographic locations, clouds, and the reading of weather maps. The effects of weather on air travel, weather forecasting, clouds, winds, and storms are considered. Sections deal with the atmosphere from the standpoint of physiology, psychology, sociology, pathology, and geography.

Japanese Aircraft, by John Stroud; The Harborough Publishing Company, Ltd., Leicester, England, 1945; 63 pages, 25*s*.

In conveniently arranged form this book gives data on Japanese military aircraft. Specifications, informative comment, photographs, three-view silhouettes, and colored drawings are used to describe the fighters and bombers. Shorter sections deal with transport and training aircraft, and the seven principal Japanese aircraft-manufacturing companies. A brief English-Japanese glossary of aeronautical terms is included.

Vital Problems of Air Commerce, edited by Lucien Zacharoff; Duell, Sloan and Pearce, New York, 1946; 338 pages, $3.00.

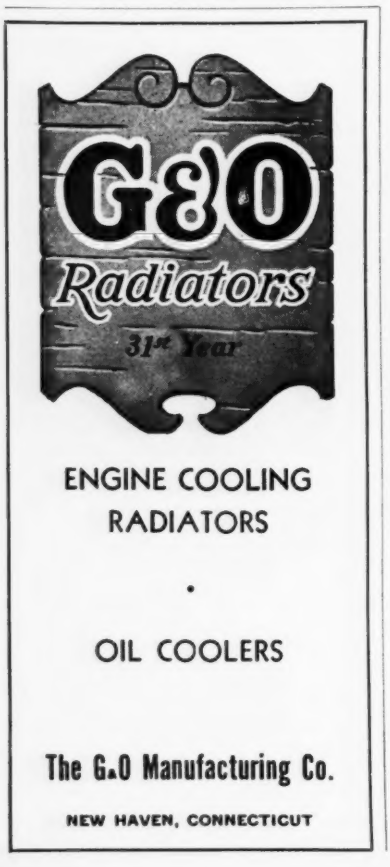
Thirty-one speeches have been selected from those presented at the forums and panel discussions of the Aviation Section of the New York Board of Trade during 1944 and 1945. The book covers a wide variety of subjects which are discussed by leaders in their fields from the technical, political, economic, and financial points of view. United States air policy, various aspects of international and domestic air transport, air cargo, airports, private flying, finance, and legal problems are among the subjects treated. The editor has gathered them in one volume because of his belief that these problems have a national interest and should reach a wider audience. He has done a valuable service in presenting different points of view on aeronautical questions of such importance while they are still in the process of solution.

U.S. Army Aircraft 1908–1946, by James C. Fahey; Ships and Aircraft, New York, 1946; 64 pages, $1.00.

The publication lists U.S. Army airplanes from 1908 to 1946, compiled from official documents and original source material. The development of each military type is presented in tabular text and pictures, model by model, arranged chronologically or by builders, in three sections covering the period 1908–1918; numerically by model designation in a section devoted to numbered types, 1919–1924; and modern models, including special-type airplanes and gliders, 1924–1946.

Careers in Aviation, by Samuel Burger; Greenberg, Publisher, New York, 1946; 209 pages, $2.75.

Written to aid those who are seeking positions in the aviation industry, this book provides the reader with information to guide him in the choice of a career. Aviation opportunities are discussed, and the general requirements for different classes of work are outlined. Positions obtainable in commercial, industrial, and Government aviation are described, and also the opportunities in aviation schools. One chapter is devoted to women in aviation. A selected bibliography is included.



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Personnel Opportunities

This section is for the use of individual members of the Institute seeking new connections and organizations offering employment to aeronautical specialists. Any member or organization may have requirements listed without charge by writing to the Secretary of the Institute.

WANTED

Electronics Engineers, Project Engineer—The U.S. Naval Air Station, Quonset Point, R.I., has vacancies for highly qualified and experienced electronics engineers, P-5, at $5,905.20 per annum; P-6, at $7,102.20 per annum; and a project engineer, P-3, at $4,149.60 per annum. Applications (Civil Service Form 57) are desired from persons who feel that they are capable of performing at the above-mentioned professional level, and should be mailed to the Recorder, Board of U.S. Civil Service Examiners, U.S. Naval Air Station, Quonset Point, R.I.

Chief Engineer—Experienced engineer needed to assume responsibility for stress analysis and C.A.A. approval of new personal airplane. Initial position would be as Chief of Structures, with opportunity to assume Chief Engineer's position if experience and other qualifications are satisfactory. Opportunity for investment in the company if desired. Address replies to The Dansaire Corporation, Dansville, N.Y.

Mechanical Engineers, Designers and Layout Draftsmen—Having a minimum of 3 years' industrial experience on small electromechanical devices. Positions are in the Engineering Division of the makers of the Link Trainer. Engineering degrees or equivalent are required for engineering and designing positions. Forty-hour week allows leisure to enjoy area's many outdoor activities. Wages paid are equal to, or above, locality average. Send all particulars to Personnel Manager, Link Aviation Devices, Binghamton, N.Y.

Aeronautical Engineers—The Board of U.S. Civil Service Examiners, U.S. Naval Air Station, Quonset Point, R.I., announces that a limited number of applications are now being accepted for the position of Aeronautical Engineer (Power Plants), P-3, $4,149.60 per year. Applicants must show that they have successfully completed a full 4-year course leading to a Bachelors' Degree in Aeronautical Engineering in a college or university of recognized standing; or 4 years of successful progressive aeronautical engineering experience. In addition, applicants must show 3 years of progressive professional aeronautical engineering experience involving aircraft power plants. Graduate study in aeronautical engineering involving aircraft power plants successfully completed in a college or university of recognized standing may be substituted for experience year for year, up to a maximum of 3 years. Applicants applying for this position should mail Standard Civil Service Form 57 to: Recorder, Board of U.S. Civil Service Examiners, U.S. Naval Air Station, Quonset Point, R.I.

Research Engineer—Responsible position open with small corporation engaged in development engineering on aircraft instrumentation and control systems. Background of mechanical engineering or applied physics required. Address inquiries to Box 388, Richmond, Va.

Engineers and Physicists—Advanced positions are open to high-type engineers and physicists with master's or doctor's degrees to perform research, development, and design studies relating to high-speed aircraft and missiles. Salaries commensurate with ability. Excellent working conditions. Address inquiries to R. C. Blaylock, Chief Engineer, Curtiss-Wright Corporation, Airplane Division, Columbus 16, Ohio.

Engineers, Technicians—The National Advisory Committee for Aeronautics at Langley Field, Va., has openings for engineers and technicians to work on the design, development, and application of instruments for use in its wind tunnels and other aeronautical research facilities. Currently, a large portion of the instrumentation is devoted to speeds considerably greater than the speed of sound and to the development of pilotless aircraft and guided missiles. There are openings for professional men ranging from a starting rate of $2,644.80 per annum for men just out of college to $4,902 per annum for men with experience in instrument work. There are also openings for instrument mechanics and instrument makers, ranging from $2,034 per annum for men who have had a minimum of 2 years of experience, other than routine production, in construction, test, installation, or maintenance of mechanical, electrical, electronic, or optical instruments to a $3,090 per annum starting rate for first-class journeymen. Apply to Instrument Research Division, National Advisory Committee for Aeronautics, Langley Field, Va.

Aeronautical Engineers—To participate in design and development program of new aircraft in Engineering Branch. Immediate openings for aerodynamicists, flight test engineers, power plant engineer, design draftsmen. Address inquiries to Edo Aircraft Corporation, College Point, N.Y., Attention of Mr. C. J. Libby, Administrative Engineer.

Graduate Aeronautical Engineer—Small expanding engineering and manufacturing organization located in Houston, Tex., has a job opportunity for a recent engineering graduate interested in the design and/or manufacture of personal airplanes. Write giving complete pertinent information, including interests, experience, and starting salary expected to Anderson, Greenwood and Company, Sam Houston Airport, Houston, Tex.

Engineering Personnel—Engineers with 5 or more years of helicopter experience in any one of the following lines: aerodynamics, stress analysis, vibration analysis, project engineering, and engineering flight test. Apply by letter to United Helicopters, 625 El Camino Real, Palo Alto, Calif.

Heating and Ventilating Engineer—Senior heating and ventilating engineer, familiar with the principles of heat exchange and air conditioning applicable to aircraft design, is required to act as Group Leader in the Design Office of a large aircraft manufacturing company in Montreal. Candidates should be graduate electrical, mechanical, or aeronautical engineers and should have at least 5 years' experience, including 3 years' specifically in the above work, and 1 year of supervisory experience. Applicants should write giving details of educational background, experience, salary expected, and availability to Canadair Limited, P.O. Box 6087, Montreal, Quebec, Canada.

Mechanics—Line Maintenance—Forty hours (rotating shifts). $1.26 per hour with periodic increases. Four years' minimum experience in multi-engined aircraft (C-54 experience desirable). Preference given for experience in electrical or instrument line maintenance and Aircraft and Engine Licenses. Contact Personnel Department, American Overseas Airlines, LaGuardia Field, N.Y.

Mechanics—Foreign Service: Paris, Iceland, Azores, Greenland. Foreman, $325 per month; lead mechanics, $325 per month; mechanics, $262.50 per month; $175 in addition to monthly salary for overseas duty. One year C-54 experience minimum, with an additional 3 years' experience in line maintenance, and Aircraft and Engine Licenses. Contact Personnel Department, American Overseas Airlines, LaGuardia Field, N.Y.

Instructor—Wanted by Department of Mechanical Engineering beginning in the fall quarter to teach undergraduate courses in aeronautics and courses in heat power engineering. Must have good academic training and some teaching experience; should have practical experience in aeronautical engineering and ability to do research. Salary up to $4,500 based on training and experience. Apply to Department of Mechanical Engineering, College of Engineering, University of Kentucky, Lexington 29, Ky.

Aeronautical Engineers—Group Engineers in stress, structural test, and aerodynamics; lead and major engineers in design, aerodynamics, stress analysis, and structural test wanted immediately for development and production engineering work on feeder-line airplane (Boeing 417) and military aircraft. Write Chief Administrative Engineer, Boeing Airplane Company, Wichita Division, Wichita, Kan.

Aeronautical Engineers—Qualified Engineers are urgently needed for development work on flight test instrumentation at Wright Field, Dayton. Attractive positions are open for research engineers (electrical, electronic, aeronautical, mechanical) with previous industrial experience in aircraft instrument development. Salaries range from $2,644 to $7,102 with the additional benefits of Federal Civil Service. Applicants may submit Civil Service Form No. 57 (obtained at local Post Office) to Secretary, Civil Service Board of Examiners, Air Matériel Command, Wright Field, Dayton, Ohio. Attention: TSFIS.

Research Designer—Airplane designer, with previous experience in applied mechanics, aerodynamics and stress analysis, to lead aircraft and missile design group. Advanced degree desirable. Thorough knowledge of jet propulsion necessary. Replies will be held in strict confidence. Write Cornell Aeronautical Laboratory, Employment Office, Buffalo 5, N.Y.

Thermodynamicist—With strong theoretical background to engage in research work in the field of jet propulsion. Advanced degrees preferred. Replies will be held in strict confidence. Write Cornell Aeronautical Laboratory, Employment Office, Buffalo 5, N.Y.

Aeronautical Engineers—The U.S. Naval Air Station, Jacksonville, Fla., requires the services of several highly qualified aeronautical engineers with power-plant or structures background, and preferably with some production experience. Salaries range from $2,980 to $5,180 per annum. Applications are now being accepted. Interested persons may obtain Civil Service Application Form 57 from their local post office and forward, completely filled out, to the Recorder, Industrial Relations Department, U.S. Naval Air Station, Jacksonville, Fla.

Aeronautical Engineers—Excellent opportunities for graduate engineers in design, stress analysis, or layout now exist for personnel interested in working on commercial-type aircraft. Write, giving education and experience, to the Personnel Department, Cessna Aircraft Company, Wichita 1, Kan.

Engineers—The Army Air Forces Air Institute of Technology being established at the Air Matériel Command, Wright Field, Dayton, has sev-

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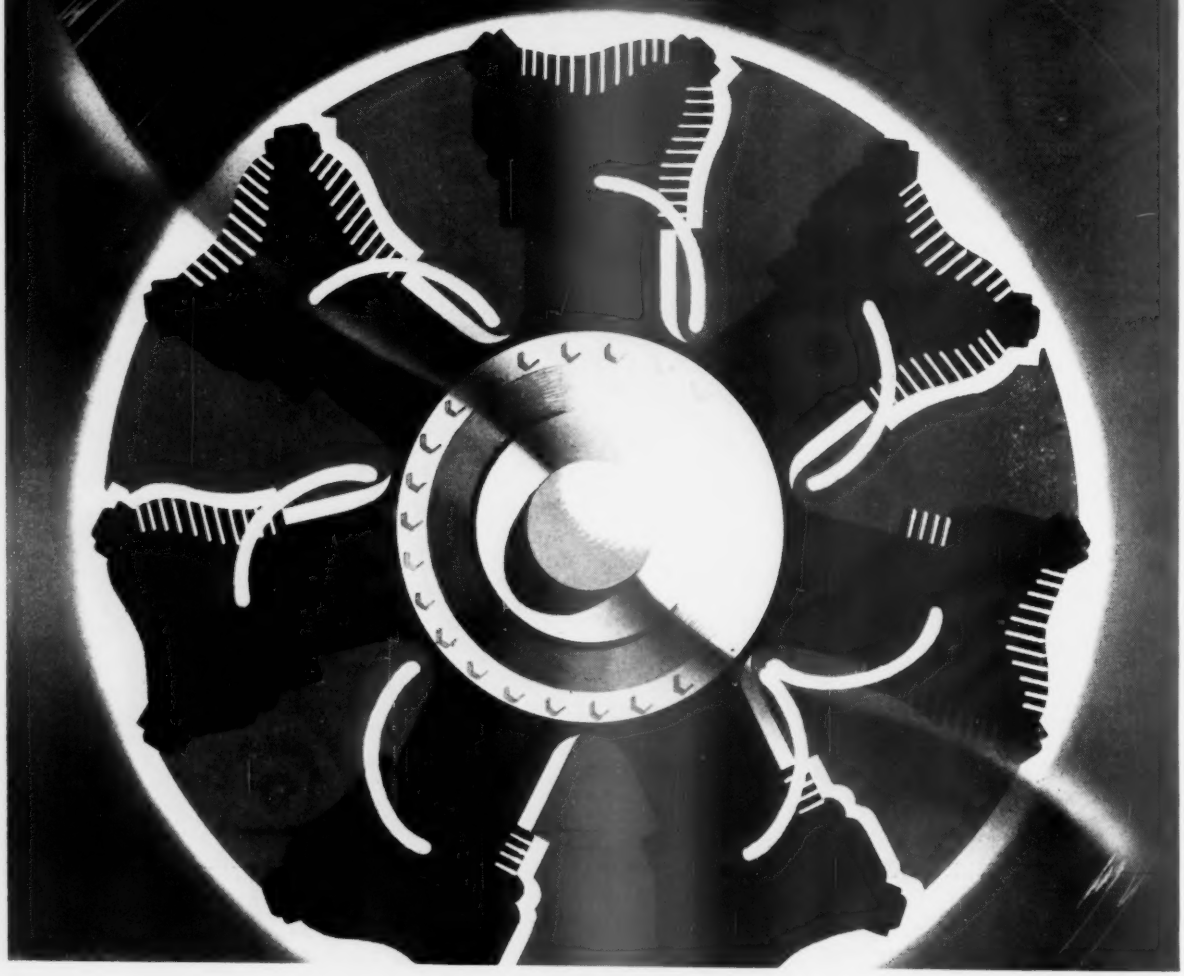

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eral openings for qualified professors and engineers to administer and to teach on a graduate and undergraduate level in the College of Engineering (Aeronautics). Starting salary ranges from $4,300 to $7,175, depending on position and qualifications. Employment will be effected in accordance with provisions in Civil Service Regulations. As faculty member, applicant should be capable of expanding into a research and consulting relationship with the various A.M.C. Engineering Division Laboratories. Write Commanding General, Air Matériel Command, Wright Field, Dayton, Ohio, Attention TSPCP-1, setting forth personal data and qualifications, education and experience; or forward Civil Service Form 57 available at post office.

Aeronautical Engineers—Thoroughly trained, experienced, and qualified to deal with problems in aerodynamics and thermodynamics. Opportunity to participate in development work arising from the application of advanced types of airplane power plant and resulting high-speed performance. Write giving education and experience, to the Industrial Relations Department, Consolidated Vultee Aircraft Corporation, Vultee Field Division, 842 South Lakewood Blvd., Downey, Calif.

Aerodynamicists—Immediate work is available for three qualified engineers with Kaiser Fleetwings, Inc. First man must be a stability and control specialist with at least 2 years' experience, some experience with problems related to flight at transonic and supersonic speed. Second man must be a specialist in aircraft performance estimation with a minimum of 2 years' experience, familiar with compressibility phenomena and with means of accounting for these phenomena in performance estimation. Third man must be familiar with general aerodynamics work and possess some knowledge of the characteristics of ram jet, pulse jet, and rocket jet engines. Good background in thermodynamics is necessary. Address reply to G. G. Cudhea, Chief Engineer, Kaiser Fleetwings, Inc., Bristol, Pa.

Assistant Professor—To teach applied mechanics, strength of materials, and fluid mechanics. A young man with M.S. degree preferred. Applicant should have special qualifications in the field of hydraulics and fluid mechanics. Opportunity to work in fluid meters research and the development of a fluid mechanics laboratory. Address inquiries to Department of Mechanics, University of Oklahoma, Norman, Okla.

Instructor in Aeronautical Engineering—To teach courses in general aeronautics and stress sections. Must have aeronautical engineering degree. Opportunity to do graduate work. Appointment for September 15, 1946. Address: Department of Aeronautical Engineering, University of Minnesota, Minneapolis, Minn.

Assistant or Associate Professor—To conduct senior and graduate courses in airplane stress and design group. Must have M.S. degree in Aeronautical Engineering and experience in industry or teaching. Appointment for September 15, 1946. Salary open. Address: Department of Aeronautical Engineering, University of Minnesota, Minneapolis, Minn.

Aerodynamicists—College graduates with sound theoretical training and at least 1 year of graduate study in compressible subsonic flow and supersonic flow to do research and test work in the Supersonic Wind Tunnel of the Ballistic Research Laboratories, Aberdeen Proving Ground, Maryland. This is by far the largest operating supersonic wind tunnel in the country. Remuneration in accordance with qualifications. Write, giving education and experience, to The Commanding General, Aberdeen Proving Ground, Maryland, Attention: Director, Ballistic Research Laboratories.

Technical Representatives—To perform industrial representation within their resident state, county, or city for manufacturers and associated concerns throughout the country. Must have permanent position with an established company and complete domestic and technical information. Address inquiries to George E. Harris Associates, Rooms 314-318, Administrative Building, Municipal Airport, Wichita, Kan., Attention: G. E. Harris.

The number preceding the notices represents the Box Number of the Institute of the Aeronautical Sciences to which inquiries should be addressed.

Research Engineer—Theoretical Aerodynamicist or Thermodynamicist with advanced degree to engage in research on certain high-speed developments. For details write Box 1-T, Richmond 2, Va.

598. Aeronautical Engineers—Immediate positions open in Washington, D.C., for aircraft engineers with practical experience in preliminary investigations of new aircraft designs and airplane performance. Salary between $4,149 and $4,902 per year. In applying please give brief sketch of personal qualifications, education, and experience.

597. Aeronautical Engineers—Immediate positions open in Washington, D.C., for aircraft engineers with practical experience in structural design and research. Salary between $3,397 and $5,905 per year. In applying please give brief sketch of personal qualifications, education, and experience.

595. Modelmakers—Craftsmen skilled in the use of hand and power tools to close tolerances wanted for model work by growing industry in the West. Experience in making wind-tunnel, free flight, and tow basin models for Army, Navy, N.A.C.A., or industry desirable. Position permanent. Please state full particulars in first letter, including age, experience, references, and salary desired.

593. Resident Sales Engineers—Near New York, Boston, Bangor, Albany, Scranton, Philadelphia, Richmond, Roanoke, Columbia, Jacksonville, Birmingham, Nashville, Cincinnati, Pittsburgh, Buffalo, Detroit, Chicago, St. Louis, Little Rock, New Orleans, San Antonio, Dallas, Oklahoma City, Kansas City, Omaha, Minneapolis, Helena, Casper, Denver, Albuquerque, Phoenix, Salt Lake City, Carson City, Boise, Seattle, Portland, San Francisco and San Diego. If you live within a reasonable distance from these cities and are willing to represent a new young firm of consultants in them and surrounding communities on a straight commission basis, kindly submit your complete background and present status.

591. Engineer—To direct production. Graduate engineer, or equivalent, with practical production experience, wanted to direct manufacturing activities of medium-sized East Coast concern specializing in precision equipment sold in the aircraft and industrial fields. Man desired should be capable of coordinating engineering development with production requirements; also of coordinating production control, tool design, costing, etc. New York City vicinity. Salary commensurate with experience.

586. Project Engineer—To handle a complete helicopter development program. Should have not less than a Bachelor's degree in engineering and at least 5 years of rotary wing experience. In replying, applicants should submit complete background information and a recent photograph.

584. Chief Project Engineer and Several Project Engineers—For design and development work in various forms of jet propulsion. Prefer men having some experience with rockets, ramjets, pulse-jets or turbojets. Experience in performance analysis desirable. Eastern location. Reply by letter stating details of education, experience, personal data, and salary desired.

583. Aerodynamicist—For design and development of diffusers, nozzles, compressors, etc., in connection with jet propulsion development program. Prefer man familiar with transsonic and supersonic airflow. Eastern location. Reply by letter stating details of education, experience, personal data, and salary desired.

582. Thermodynamicist—Preferably with internal combustion experience for development work in connection with various forms of jet propulsion systems, including cycle analysis, combustion chamber design, etc. Familiarity with rocket and jet fuels desirable. Eastern location. Reply by letter stating details of education, experience, personal data, and salary desired.

581. Aeronautical Engineer—With airplane stability and control experience wanted by electronics company engaged in guided-missiles development. Location in vicinity of Boston. Good opportunity for right man.

579. Aeronautical Engineer—A leading Eastern light aircraft accessory manufacturer desires to augment its engineering division with a young aeronautical engineer. Applicant must have knowledge of aircraft structures; hydraulic and electrical systems; mechanics of gases; imaginative and inquiring mind with the ability to solve current problems in light aircraft accessory design. $4,500 starting salary. Recent photo and background in first letter.

571. Executive Engineer—Established West Coast helicopter company offers unusual opportunity for highly qualified engineer. Responsible for administration, programming, and control of engineering. In addition to technical training and experience, must have administrative and organizing ability and knowledge of production and procurement problems. Write full qualifications.

568. Personnel—An expanding southern New England helicopter company has positions available in several fields for personnel interested in rotary wing aircraft. Experience in helicopters is desired but not necessary. Give full education and experience.

567. Engineers—One of the largest engine companies located in Midwest engaged in extensive and continuing development program on nonrotating aircraft propulsion engines has openings for the following personnel:

Development Engineer—An idea man with good theoretical and practical background to direct activities of engineering group devoted to preliminary design and analysis.

Thermodynamicist — Research - minded with good theoretical background, advanced degrees preferred.

Vibrations and Structures Engineer—A man with aircraft and aircraft engine design experience, with an interest in analytical vibration problems.

Instrumentation Engineer—A man with a good understanding of wind-tunnel instrumentation, familiar with electronic, optical, and other instrumentation means suitable for use in studying aerodynamic and thermodynamic problems.

Mechanical or Aeronautical Engineers—Up to 5 years' experience, interested in research and development activity in a rapidly expanding program.

Aerodynamicist.

Physicist.

555. Assistant, Associate, or Professor of Aerodynamics—To teach graduate courses in aerodynamics, especially aerodynamics of gas turbines, at well-known eastern school. Opportunity to engage in research. Advanced degree required and research experience preferred.

554. Aerodynamicists and Aeronautical Engineers—Positions available for highly qualified technical personnel with good theoretical background to engage in development and test work in stability and control, high-speed aerodynamics, and axial-flow compressors. Salary in accordance with qualifications. In reply please give brief summary of personal qualifications, education, and experience. As required by the Civil Service regulations now in effect, preference in appointments to these positions will be given in the following order: (1) persons entitled to ten-point military preference, (2) persons entitled to five-point military preference, (3) former Federal employees, (4) persons who do not come under (1), (2), or (3).

550. Engineer—Qualified engineer capable of serving as liaison between development engineer-

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ing and factory production in aircraft electronics and related fields. Background of shop practice essential to assist and guide design engineering in production methods. Unusual opportunity for permanent position.

548. General Manager—For large and active aircraft concern located in the East. In addition to proved administrative ability and all other qualities suited to a general manager must have many years of successful aircraft production experience. Good position for a good man. State qualifications. Correspondence will be kept confidential.

538. Engineers—Experienced engineers wanted for project engineering and design evaluation work on pilotless aircraft. Aeronautical graduates with training or experience in electronics preferred. Location Washington, D.C.

534. Draftsmen—Personal plane manufacturer and government contractor located in New York Metropolitan area is seeking qualified airplane draftsmen. Engineering degree not necessary although aeronautical experience desirable.

529. Service Manager—For major personal plane manufacturer located in New York Metropolitan Area. Good opportunity.

526. Aeronautical Engineers—Positions open in Washington, D.C., for aerodynamicists with design and research experience in high-speed aerodynamics and stability and control or aircraft performance analysis. Salary between $4,149 and $4,902 per year. In applying, please give brief sketch of personal qualifications, education, and experience.

518. Power-Plant Design Engineer—For supervision of design of power-plant installations. Will also supervise design of mechanical equipment, including heating and ventilating equipment, hydraulic, vacuum, and oxygen systems and cabin supercharging systems in airplanes. Must have mechanical or aeronautical engineering degree with over 7 years' experience in this work in aircraft industry. Position available in Midwest airplane company.

512. Assistant Professor of Aeronautical Engineering—To teach courses in aircraft design and aircraft structures in aeronautical engineering department of large university in Southwest. Opportunities for research in structures and in newly organized Navy Ordnance program provide for full year-round employment. Applicants should submit detailed record of education and experience.

511. Aeronautical Engineers—To teach mathematics, primary and advanced aeronautical engineering subjects including design and stress analysis in a Midwestern university.

490. Assistant or Associate Professor—Sought by Aeronautics Department of Engineering College to teach undergraduate and graduate courses in aerodynamics, aircraft structures, or aircraft propulsion. Must have good academic training and teaching experience; constructive interest in aeronautical research and development, preferably industrial or laboratory experience in this field. Starting salary range: $3,000 to $5,000, depending upon qualifications.

AVAILABLE

Engineer—B.S. in M.E., Ae.E.; desires responsible executive position, preferably with personal plane manufacturer. Has 20 years' design, production, and executive experience which merited brief biography in *Who's Who in America*. Address inquiries to P.O. Box 503, Mt. Vernon, N.Y.

600. Aeronautical Engineer-Pilot—Associate in Arts in Ae.E.; Chinese, 23 years of age, single. Cambridge Senior School Certificate (local), London, England. Experienced in layout, structural design, C.A.A. requirements, forging design. Has pilot's license and experience in maintenance of light aircraft and engines. Can translate French and Spanish (speaks both slightly), and speaks English fluently. Now Assistant Stress Analyst to Staff Engineer in well-known aircraft company. Desires engineering work with aviation company outside the United States. Willing to teach elementary engineering subjects. Will consider sales offer. Photograph, certificates sent on request.

599. Engineering or Management Executive—Engineer with 26 years' experience in aircraft engineering and manufacturing seeks responsible engineering or management connection with aircraft manufacturer. Previous positions in $12,000 range. Outstanding design, organizing, and managing ability. Familiar with Army, Navy, and commercial requirements.

596. Technical Editor-Writer—Graduate Mechanical Engineer. Has 1 year's experience in operation of low-turbulence wind-tunnel testing airfoils, flaps, and ailerons. Also has 4 years' experience writing and editing technical training material consisting of description, operation, inspection, maintenance, and test of airplane engine, flight, and navigation instruments. Desires position as editor-writer of technical material.

594. Pilot-Engineer—Degrees in both Aeronautical and Mechanical Engineering. Three years' experience in flight test engineering and 1 year in wind-tunnel testing. Experience in both performance and flying qualities flight-test methods. Commercial pilot with single and multi-engined land ratings. Total time 1,700 hours with majority military in wide variety of types. Interested in flying or combination of flying and engineering in Middle West or West Coast aircraft company, preferably in connection with commercial-type aircraft.

592. Engineer—Four years' experience as engineer and layout draftsman on aircraft construction; desires position as project group leader; location in Eastern States preferred.

590. Salesman—Age 26. Education in Eastern preparatory school and university. Three years' air-line engineering, domestic. Desires position in aircraft sales (airplanes and/or airplane parts). Excellent personal and business contacts.

589. Representative—Chinese, technical engineer with degrees in Ae.E. and M.E. Completed Army Air Forces A. and E. maintenance and pilot training. 3 years' factory experience in aircraft engine development works includes 1 year of jet propulsion and gas turbine. Formerly Government official. Desires responsible engineering position or representation to China.

588. Management or Administration—Twenty-seven years old, single. A.B. degree, University of Pennsylvania. Major in political administration, courses applicable to business administration. Courses in industrial engineering including industrial relations, business and government, organization and organizational structure. Aeronautical engineering courses in elementary aerodynamics, performance calculation, aircraft drafting and engineering. Two and one-half years in aircraft testing in present position. Desires permanent position on junior level in management or administration with opportunity for advancement. Philadelphia area.

587. Aeronautical Engineer—B.S. in Aeronautical and Mechanical Engineering. Five years' experience as aircraft service engineer, including overhaul, manufacturing, and aircraft modification. Ex-Marine Captain. New York area preferred.

585. Administrative—Air Force Major, staff intelligence officer. Age 31, married, college graduate. Five years' industrial experience prior to war. Desirable contacts in Philadelphia area. Some knowledge of German and French. Manufacturer's representative or agency.

580. Engineer—E.E. Seeks research, development, or administrative position in New York City or Long Island. Ten years' experience includes aircraft controls, ignition, servomechanisms and industrial electronics. Qualified to hold position requiring considerable administrative or supervisory ability. Will accept position of lesser responsibility with reasonable assurance of advancement.

578. Aeronautical Engineer—B.S. in M.E., aeronautical option, 1942. Four years' experience large-scale wind-tunnel testing and research work on propellers, air-cooled engine installation, airplane stability and control and general aerodynamics. Now engaged in supersonic flight-test work. Desires position in Middle West. Prefers research and development work in high-speed aerodynamics.

577. Sales Engineer—Graduate aeronautical engineer with 2½ years' experience in aircraft design engineering, including liaison, desires a position as sales engineer. No objection to foreign service.

576. Aeronautical Engineer—B.Ae.E. Age 26; married. Six years' experience. Group leader and project engineer for past 4½ years. Has done basic jet research and complete helicopter design. Desires position with responsibility in New York area.

575. Aeronautical Engineer—Six years' diversified experience, including aircraft inspection, teaching, original research and development work. Familiar with stability and control problems and latest aspects of supersonic aerodynamics. Some graduate work. Will consider responsible position as project engineer or administrative assistant with progressive organization.

574. Aeronautical Engineer—B.A.E.; age 27. Three years' experience in layout, design, stress analysis, static test, shop liaison, and quality salvage with a leading aircraft manufacturer. One year at a Naval Air Station as Engineering Officer in the Assembly and Repair Department. Desires a responsible position in production management. East Coast preferred.

573. Aeronautical Engineer—Age 29. B.S. in Mechanical Engineering. Graduate of A.A.F. Post Graduate Engineering School. Two years' experience as aeronautical engineer with large aircraft company. Five and one-half years with Engineering Division, A.T.S.C., Wright Field, in charge of development plastics for aircraft structures. Wide acquaintance with key personnel aircraft, plastics and materials manufacturers, and A.A.F., Bureau of Aeronautics, and other government agencies. Desires responsible position in engineering management or management of development of materials and products.

572. Executive Assistant—Nine years' aviation background consisting of complete course in air-line operations, employment with major air line as meteorologist and trainee dispatcher, and command and important staff assignments in A.A.F. Additional training in basic engineering subjects, manufacturing and business administration; nonaviation experience in office management, selling, manufacturing and organizational consulting. Desires connection as assistant to air-line executive in operations or administration but will consider other positions where versatility and broad knowledge, plus dependability and mature thinking are required.

570. Maintenance Engineer—B.M.E., 1939. Five years' varied experience on transoceanic aircraft with air line. Accumulated 2,700 hours as flight engineer. Speaks Portuguese and German. Holds valid A & E and Private Pilot's license. One and one-half years with Army Air Transport Command. Interested in position with air line or with manufacturer designing transport aircraft.

569. Washington Representative—Reserve Officer and senior pilot desires to handle aviation concerns' Washington business. Fourteen years' industrial experience in aeronautical design, manufacture, testing, and operation of aircraft, engines, and accessories, plus 6 years' military duty in very responsible executive, engineering, and maintenance billets. Reliable, resourceful, and well established in Washington.

566. Graduate Engineer—Eight years' experience in materials and process, stress analysis, and structural testing. Desires position in similar or production field with aircraft, accessory manufacturer, or air line. Locality immaterial.

565. Engineer and Executive—Almost 30 years' experience on airplane and accessory de-

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Prominent Aircraft Company, Eastern United States, needs men with the following qualifications:

M.S. in M.E. or A.E. (B.S. accepted if experience warrants). Two to five years in industry (Research Laboratory experience accepted from certain laboratories). Work should include thermodynamics, fluid dynamics, metallurgy, heat transfer. Experience also desired in hydraulics and automatic controls. Aerodynamics desired but not essential. Centrifugal pump or supercharger work also desirable. One M.S. in Ch.E., combustion and metallurgy experience.

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Applicants must hold A & E certificates. Age 21 to 35. Four years' diversified maintenance experience on heavy multi engine type aircraft or graduate aeronautical engineers one year. Must pass flight physical. Have proof of citizenship for passport procurement. Address inquiries to:

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Trans World Airlines
AAF Annex #1, Bldg. T-7, Room 1534
National Airport, Gravelly Point
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Prominent Aircraft Company, Eastern United States, needs men with following qualifications:

Experienced engineers with Bachelor's, Master's, Doctor's degrees in Electrical Engineering, Physics, Mathematics. At least two years' experience in design and development of radar and television systems, automatic computers, servomechanisms, target seekers, etc., required. Positions open for preliminary and detail design, research, and development of guided missiles under Army and Navy contracts.

Starting salary commensurate with experience. Address Box 602.

sign, airport selection and layout, and airplane operations engineering. Good organizer and manager, sound business experience, capable technical writer, wide knowledge of materials and processes.

563. Aeronautical, Mechanical, and Electrical Engineer—Electrical Engineering degree; 37 years old. Thirteen years' experience. Automotive parts supplier's experimental shops (holds journeyman's rating as machinist); aircraft landing gear design and testing for accessory manufacturer; aircraft hydraulic design and administrative engineering for aircraft manufacturer; sales engineer for aircraft landing gear; industrial hydraulic design; aircraft seat design and testing. Complete résumé on request. Desires position as Sales Engineer. Administrative Engineer, Design Engineer, Technical Consultant, or other in aircraft or other lines in Los Angeles area with aggressive organization.

561. Teacher—M.S. Ae.E., 5 years' teaching senior and graduate courses in airplane structures and design, 9 years' industrial experience in design and stress analysis. Has done considerable amount of research for industrial companies and Government agencies.

560. Industrial and Aeronautical Engineer—B.S. in Industrial Engineering, major in Aeronautical Engineering from Iowa State College, 1943. Age 25. One year's experience with large West Coast aircraft concern. Served as an Aeronautical Engineering Specialist for over a year in the Navy Air Corps. At present, Production Officer at a Naval Air Station in charge of all repair shops and supervision of 400 men. Work includes checks, maintenance, repairs, and overhauls of latest-type Navy aircraft. Desires responsible position in the production department of an aircraft firm. Would also accept stress analysis or aerodynamicist position.

558. Aeronautical Engineer—B. of Aero.E., New York University, 1944. Two years of liaison engineering experience in U.S. Navy, plus previous limited association with large manufacturer as Aerodynamicist and Flight Test Engineer. Desires position with small organization in New York area, not necessarily aircraft, to do design and development work.

557. Aeronautical Engineer—B. of Aero.E., New York University and 2 years of law study. Four years' experience in static test and structural flight test experimental work on Naval aircraft. Experience in all phases of experimental work involving instrumentation and tests of aircraft structures. Plans to complete LL.B. degree in 1 year of evening school. One year part-time experience with patent attorney. Desires position in New York Metropolitan or Los Angeles area as patent engineer or aeronautical engineer. Opportunity desired for working into engineering-law position.

556. Production and Service Engineer—Nine years' practical experience in aircraft planning, scheduling, manufacturing processes, and service engineering with large eastern aircraft manufacturer. Experience includes planning and scheduling of production aircraft and spare parts, improvement and simplification of manufacturing processes, especially machining processes, and the compilation and editing of erection and maintenance manuals for production and experimental aircraft. Veteran of World War II. Desires position of administrative capacity in production management or service engineering.

553. Aeronautical Engineer—Canadian, age 28, married. Four years' responsible work in aircraft manufacturing and air-line engineering; previous writing and administrative experience. Broad educational background, including American. Thoroughly familiar with both American and British airworthiness requirements. Interested in development engineering. Continental or foreign location acceptable. West Coast preferred.

551. Aeronautical Engineer—General design experience on wood and metal aircraft, Army, Navy, and C.A.A. Considerable electrical and radio experience. Present standing Electrical and Radio Group Leader. Desires salaried position in vicinity of New York City.

547. Aeronautical Engineer—Assistant Professor of Aeronautical Engineering at large state university desires change. Has M.S. in Aeronautical Engineering; 8 years of teaching; industrial, consulting, and research experience in many phases of aeronautical engineering. Private pilot. Prefers university position with research and consulting possibilities. Will consider responsible industrial position.

546. Field or Sales Engineer—Seven years' experience in foreign and domestic field in installation and sales engineering for major engine company. Desires field or sales engineering position with engine or air-frame company. Well established contacts on West Coast and Buffalo area. References and background available upon request.

545. Aeronautical Engineer—Six years' experience in engineering as Assistant Chief of Structures, Project Engineer, and on Army aircraft maintenance. Desires responsible engineering position with company developing roadable-type aircraft.

544. Aeronautical Engineer—B.A. in Ae.E. Recently discharged from U.S. Army. One year's experience in design of wooden gliders and metal cargo planes. Six months' experience in research analysis in jet propulsion. Also experienced in helicopter design. Excellent references.

543. Experimental Test Pilot—Five years of experimental and production flight-testing of fighter, dive bomber, and attack-type aircraft. All experience has been with contractors. Approved by Army and Navy for demonstration test work. Commercial license, single- and multi-engined ratings, instrument rating, instructor's rating. Recent experience in jet-propelled and other high-performance experimental aircraft. Interested in flying or nonflying position offering future.

542. Sales and Service Engineer—Ten years of varied experience in the aircraft industry, both in fixed and rotary wing. Four and one-half years' experience in Sales Engineering, remaining experience in aircraft design. Desires connection with personal aircraft manufacturer or sales agency in the New York area. Holds valid private pilot certificate.

541. Translations—Aeronautical engineer and physicist would translate German technical papers and books into English. Thoroughly familiar with terminology in both languages.

540. Executive Accountant—Desires to join a progressive company as Treasurer, Controller or financial officer, or their chief assistant. Eight years' experience as Treasurer, Secretary. Also in plant management with one of the largest light-plane manufacturers. Has splendid banking connections. Desires to return to the aviation field. Willing to go to any part of the country, but prefers East or Middle West. Salary open, depending on future possibilities. Available within 30 days.

539. Technical Writer—Editor—Writing problems expertly handled by former editor of aircraft manuals. Low cost, confidential service on any written work from minor corrections to rewriting and ghostwriting. Reports, articles, speeches, and monographs guaranteed to be put into clear, forceful, letter-perfect English.

533. Production Executive—Aeronautical Engineering degree, M.I.T. graduate. Industrial management experience. Eight and one-half years in the aeronautical field, including engineering design and layout, research and process, manufacturing and matériel, engineering officer U.S. Navy. Seeks executive or administrative post in field service and maintenance, factory and production management, matériel, or as line assistant to top executive. Available one month's notice.

532. Aeronautical Engineer—Bachelor of Aeronautical Engineering Degree from New York University with honors. Age 25. Two years' experience in design and research of aircraft propellers involving original administrative work on all phases of propeller design, theory, flight, testing, and production. Most original designs used by the services during the war. Flying experience. Two years' administrative experience as an officer in the U.S. Navy. Familiar with all phases of aviation. Desires responsible position in development, research, or administration in aeronautical organization with future. Has the initiative and ability to get things done. New York area preferred but not necessary. Excellent references.

531. Management Executive—Mechanical Engineer (1924), now Production Manager of medium-sized organization. Twenty-two years' practical experience in aircraft production, 12 years as executive in production control, manufacturing and plant management. Familiar with latest metal and wooden aircraft manufacturing techniques. Able leader, efficient organizer, experienced in labor relations. Expert in setting up and operating production programs of new aircraft. Writes and speaks fluently English, French, and German. Desires permanent position with well-established organization where knowledge, experience, initiative and results are of prime importance.

530. Design Engineer—Seven and one-half years' well-rounded aircraft design experience, including 4 years' rotary wing. Engineering administrative experience. Three years' experience power plant; group leader, controls; group leader, preliminary design; design engineer, general. Location open.

525. Aeronautical Engineer—Age 32. Professor of Aeronautical Engineering with 5 years' administrative experience as head of department in large engineering college. Industrial experience. Experience in all phases of theoretical and applied aerodynamics, performance, stability, and preliminary design. Will consider responsible position with accredited college or university, research organization, or industrial concern.

524. Electrical and Aeronautical Engineer—Has done graduate work in electrical and aeronautical engineering. Four years' experience as Chief Inspection Supervisor of a leading aircraft factory. Certified Ground Engineer. Desires contact with interested aircraft manufacturers or air lines for business enterprise in the East.

523. Aeronautical Engineer—B.A.E., New York University. One year aeronautical research experience. Four years' stress analysis, liaison, design, production expediting with two large aircraft manufacturers. Familiar with aircraft fabrication practice. Desires responsible production management position.

522. Mechanical Engineer—Native Polish; Master of Science degree in Engineering. Would like to translate Polish and Russian scientific and technical papers.

521. Manager—M.I.T., 1922, Engineering, Administration, Mechanical and Electrical Engineering Option. Twenty-three years' experience in industry as Industrial Engineer, Plant Engineer, Production Manager, General Manager. Last 5 years with prominent U.S. corporation as General Manager in Divisions manufacturing aircraft generators, motors, controls, and marine navigational instruments and mechanisms. A complete résumé will be sent upon request.

517. Aeronautical Engineer—Five years' experience with a leading aircraft manufacturer. Extensive experience in specification writing, weight and balance control, layout and design. Inventive ability and production minded. Experienced in supervising a large group. Desires a permanent and responsible design position in progressive organization in New York area where his experience and abilities can be fully utilized.

353. Industrial Engineer—B.S.M.E. Eleven years' experience in selecting equipment and supervising installations for aircraft manufacturing processes, including experience in production of airplane motors; also 25 years' experience in the automotive engineering and production field. In a position to do consulting work as industrial engineer.

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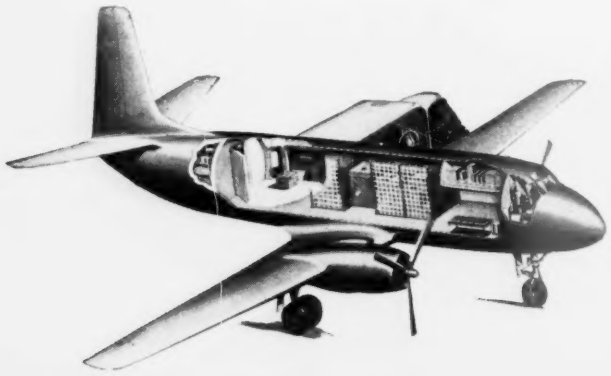

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- Operational Ceiling (at T. O. weight, one engine inoperative) . . . . . 5,000 ft.
- Maximum Operational Ceiling (T. O. weight, two engines) . . . . . 26,500 ft.
- Cruising Speed at 10,000 ft. and 60% Normal Rated Power . . . . . 246 m.p.h.
- C. A. R. Runway Length for Landing at Sea Level . . . . . 3715 ft. at Gross Weight 36,500 lbs.
- Take-off Distance, over 50 ft., at Sea Level (Water Injection) . . . . . 2550 ft.
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